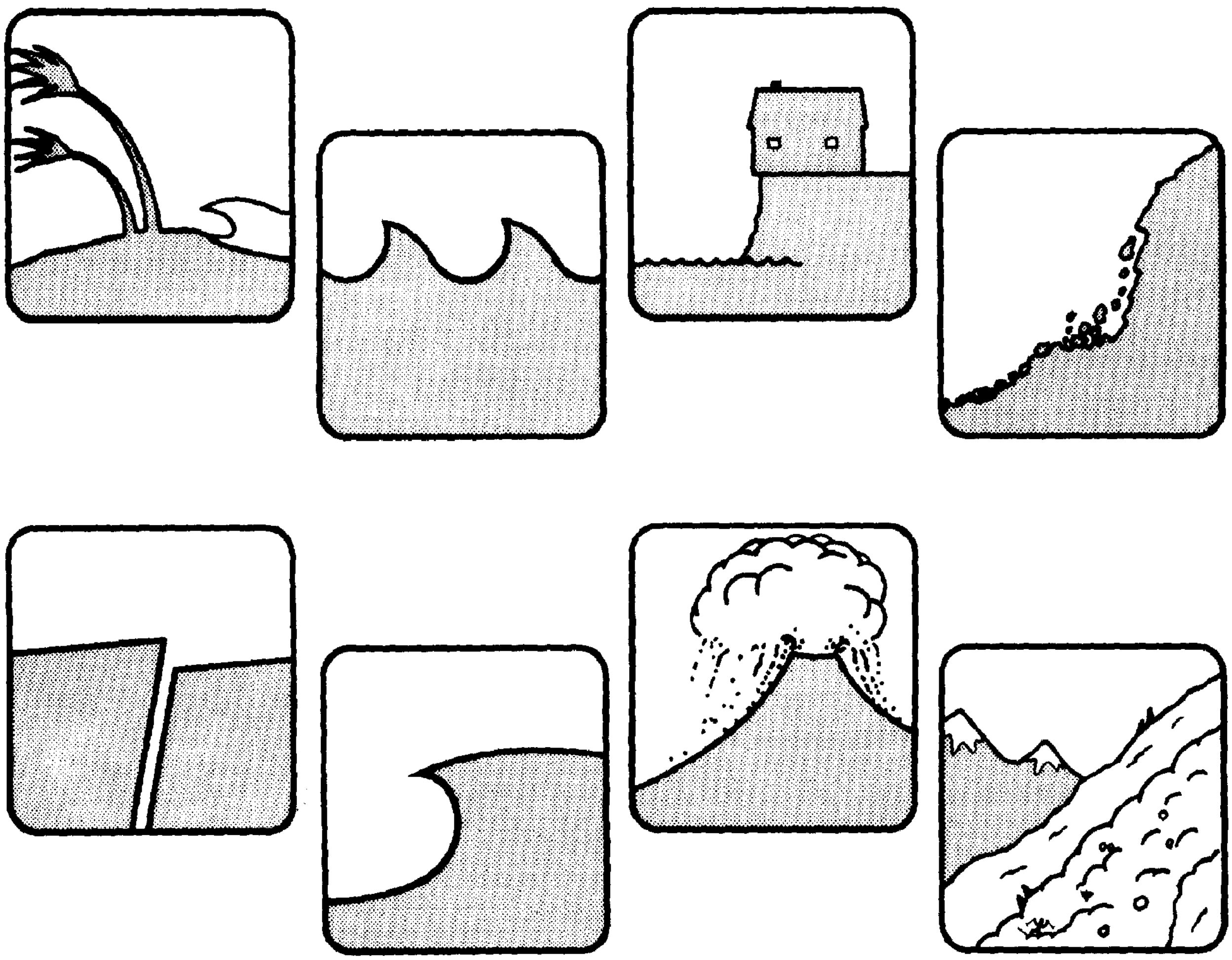
Natural Hazard Management in Coastal Areas

Washington, D.C.
November, 1976



U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Coastal Zone Management

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U.S. DEPARTMENT OF COMMERCE
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PREFACE

This is one of a series of documents prepared for the Office of Coastal Zone Management (OCZM) to provide guidance and information to coastal planners and managers on major issues they face.

Growing development pressures in coastal areas are increasing the risk to life and property from natural hazards. The fact that these events, while rare, are usually catastrophic, necessitates continued management attention. It is the long range planning and management emphasis of the Coastal Zone Management Act that provides a unique opportunity for reducing losses due to natural hazards in the coastal areas.

In order to develop management program recommendations, we asked Gilbert F. White, Director of the Institute of Behavioral Science, University of Colorado, to focus his extensive natural hazard expertise on coastal areas. An intensive effort from June until November of this year has resulted in this publication. We hope that the concepts and techniques presented are useful to coastal managers in establishing and administering effective programs, and also to others working or with an interest in the subject.

The contents are presented in handbook form to provide fast access to information by specific hazard, by coastal state, or by management recommendations. The Executive Summary encapsulates the major findings and recommendations. No attempt was made to provide in-depth scientific analysis. Readers seeking more detail should refer to the Annotated Bibliography (Section V) or seek help from the contacts listed in the Directory of Selected Federal, State and Voluntary Agencies (Section VI).

In carrying out this work the members of the staff of the Institute of Behavioral Science drew heavily upon data and experience accomulated during its earlier Assessment of Research on Natural Hazards, which had been supported by the National Science Foundation.

The description of present problems, authorities, and practices in the coastal states was greatly facilitated by the cooperation of officers of coastal zone management agencies and other state agencies who cordially supplied information and who reviewed draft materials. Their help is gratefully acknowledged.

An earlier draft of this report benefitted from review by the following people who made corrections and suggestions but who are not responsible for the final wording: Robert Beck, Wallace Bowman, Dwight R. Crandell, Leonard Crook, Robert W. Fleming, Neil L. Frank, Robert M. Hamilton, Richard Krimm, Joe C. Moseley II, George R. Phippen, Jack Schoop and Arthur J. Zeizel.

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C. "Modified Mercalli Intensity Scale of 1931" (Abridged) from Harry O. Wood and Frank Neumann, in Bulletin of the Seismological Society of America, Vol. 21, No. 4, December, 1931.

D. "Scenario of Hurricane Disaster in Miami, Florida," from Gilbert F. White and J. Eugene Haas, Assessment of Research on Natural Hazards, 1975.

E. "Barrier Islands - Hurricane Adjustments" and "Mainland Coasts - Earthquake Adjustments," Sample outlines of possible adjustments to regional natural hazard problems.

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SECTION I

EXECUTIVE SUMMARY

I. EXECUTIVE SUMMARY

Coastal areas in the United States are afflicted with a distinctive array of natural hazards. Beach erosion is unique in the problems it presents, but at one place or another along the coast problems of hurricane, tornado, flood, landslide, earthquake, tsunami, volcano, snow avalanche, and land subsidence are severe and may appear in different combinations. State management of coastal areas may be strengthened by giving explicit attention to these hazards and to the ways in which people can cope with them. In turn, the information, planning, and management activity under coastal zone management may contribute to wiser adjustments to these growing hazards.

Coastal Management in the National Picture

For the United States as a whole the annual toll taken by extreme events in nature is growing. Until recently the loss of life from floods, hurricanes and similar events seemed to be declining but appears to be on the rise again. The probability of major social dislocations from rare, catastrophic events is increasing. Coastal zone management can play a particularly significant role in this situation for two reasons.

1. The disproportionately rapid growth of population in coastal areas makes coastal areas more vulnerable to disaster than many inland areas.

2. The opportunities to reverse the trends by encouraging coordinated land and water management are more promising than in other parts of the nation.

How these opportunities are grasped will influence whether future events will include a series of national catastrophes in such places as Juneau, San Francisco, Galveston, Miami, and Staten Island, or conversely, a gradual reduction in national vulnerability to disaster.

Natural Hazard as an Essential Part of Coastal Management

A coastal zone management program must address the problems created by extreme natural events if it is to be comprehensive. The coastal managers should have some knowledge of what kind, what magnitude, and what frequency of hazard can occur throughout the coastal areas as they structure a program. Having recognized the problem, they are then in a position to propose effective means for adapting to such hazards, including information programs for the general public about hazard characteristics.

Some state coastal zone programs reflect substantial awareness of and concern with natural hazards, either independent of or in concert with one or more Federal agencies. These efforts should be carefully examined by the coastal manager for their adequacy and for their relationship with the overall coastal zone management program. In other states, weak or inadequate efforts may demand significant upgrading or restructuring to reflect current technical knowledge, to enhance popular awareness, and to incorporate a hazard management component.

The principal points at which states must deal with natural hazards in developing and carrying out a coastal zone management program are these (parenthetic references are to the Coastal Zone Management Act Regulations 15 CFR 923):

> Section 923.4 states that elements to be considered in the comprehensive program are to include floods, erosion, land stability, and climatology and meteorology.
>
> Section 923.13 points out designation of areas of particular concern are to include, among others, hazard areas due to storms, slides, floods, and erosion.
>
> Sections 923.12 and 923.14 indicate that the hazard potential as it affects reasonable and safe use of resources would be examined in delineating and establishing priorities for permissible land and water uses.
>
> Cognizant state agencies dealing with hazards are to be included in the organizational structure (923.22), may serve to administer land and water uses (923.24), and should participate in adoption of the management program (923.31).

Under the Coastal Zone Management Act Amendments of 1976 the coastal area planning is expected to develop processes for:

> Protection of and access to public beaches and other public areas.
>
> Energy facilities likely to be located in or to impact upon coastal areas.
>
> Assessing shoreline erosion and evaluating ways to control erosion.

Achieving these goals requires accurate and imaginative analysis of the hazard of extreme natural events.

Five Basic Concepts in Hazard Analysis

Hazard analysis involves five major concepts that enter into the effective design and execution of public action in coastal areas.

1) Areas potentially affected by extreme natural events must be delineated.

2) Estimates of vulnerability must recognize that human occupation of a vulnerable area always involves the beneficial use of a resource and the risk of possible loss.

3) The range of possible adjustments which can be made to a hazard must be identified. It is rare that only one course of action is worthy of consideration. The full theoretical range of possible adjustments includes:

New or improved warning systems, including preparedness plans;

Control and protection works;

Design and construction of buildings to resist wind, water or earthquakes;

Management of land to minimize loss of property or life, including land acquisition, zoning, subdivision regulations, building ordinances, and easements;

Insurance against losses;

Relief and rehabilitation assistance.

4) An assessment of present and future adjustment impacts must be made. What is chosen as an adjustment in one place and time may affect hazard elsewhere or at a later time. Adopting an adjustment such as beach protection or zoning regulations, unless properly planned, can make matters worse rather than better.

5) Reduction of exposure to more frequent events may build a potential for catastrophic losses from the very rare events. Protective works, for example, may reduce losses from more frequent events while increasing the chances of social dislocation from the very rare event.

The Principal Coastal Hazards

The situation with respect to each of the major types of extreme events may be characterized by a few observations drawn from Section II as follows:

Hurricane: More than 6 million people are currently exposed to hurricane storm surge in areas where the population is growing at a rate 3 to 4 times as fast as the national average. Although warning systems are improving, the expanding occupation of vulnerable areas and the lack of hurricane experience by young persons and relative newcomers results in an enlarging naive population and volume of property subject to damage. High winds and tornadoes may extend the impacts to much larger populations.

Flood: Valleys subject to fresh water flooding punctuate the coast in many sectors and in some places have been protected by engineering works. The requirements of the Flood Insurance Act for local land use planning in vulnerable areas have spurred the delineation of flood hazard lands and the enactment of local land use regulations to curb the increasing trend toward expansion of property in lands subject to floods with annual recurrence probabilities of one per cent.

Coastal Erosion: In about one quarter of the national shore front coastal erosion is significant and in as many as 2,700 miles it is a critical problem. In addition to protective works, dune stabilization, and beach nourishment, a wide range of land use controls is available to cope with continued erosion. Currently there is a shift in emphasis toward land use management as an alternative strategy to erosion control.

Landslide: Although landslide hazard occurs widely, there is no explicit national policy for dealing with it. Only recently and in a few states has there been extensive effort to combine land management with abatement of landslide hazard.

Earthquake: Accurate and consistent earthquake prediction has not yet been demonstrated. Other measures which promise major reduction in vulnerability to earthquake damage include the requirement of earthquake resistant construction, land use management, and preparedness planning. For most of the vulnerable areas of the country, and particularly those away from the Pacific Coast, little progress has been made in incorporating these measures into earthquake loss reduction planning.

Tsunami: Except for an improved warning system and for pioneering efforts in Hawaii there has been relatively little positive action in reducing vulnerability to tsunami waves. The amount of property and number of lives susceptible to this rare but catastrophic damage are mounting.

Volcano: The lava flows of Hawaii are relatively well defined and susceptible to prediction. Pyroclastic flows and ash flows resulting from violent eruptions are more or less predictable, are less frequent, and constitute a large but rare threat along the Pacific Coast and Alaska.

Avalanche: In a few parts of Alaska snow avalanches are a significant hazard, and only recently has there been serious consideration of a variety of measures, including land management, to deal with them.

Land Subsidence: In parts of both the California and Gulf coasts there is threat of enlarged vulnerability to natural hazards as a result of land subsidence resulting from pumping of water, oil and gas, and also generated by earthquakes.

Promising Lines of Action

State agencies have an opportunity to take action in four major directions which will have a significant effect upon adjustments to hazards and which will, in turn, reinforce efforts at coastal area management. The directions are: 1) Delineation of hazard areas, 2) defining and evaluating the options, 3) improving citizen participation, and 4) organization and coordination. The justification for action is given in Section III. The chief recommendations are the following:

1. Delineation of Hazard Areas

Some kind of designation of hazard areas should be attempted along each sector of the coast, using whatever scale and detail of map is appropriate.

Designation of hazard areas should be accompanied by explicit statements that a) reasonable use has been made of available scientific information, and b) there will be opportunity for public examination and review of the designations.

Wherever special questions about the bases for designating the degree of a hazard arise it is desirable to commission a special report by a Federal or state agency or a consulting firm.

Even though it is not practicable to show with accuracy the detailed recurrence interval of an extreme event it may be useful to estimate probabilities. Wherever practicable these probabilities should be designated as a percentage of occurrence rather than a number of years.

It is particularly important to present the results of probability analyses so that they help citizens recognize that larger and less frequent events than those of the designated probability may conceivably occur.

2. Defining and Evaluating the Options

One responsibility of coastal management officers is to make certain that all parties concerned are aware of the full range of possible adjustments to a hazard and of the costs and benefits related to each alternative adjustment.

It always should be practicable to include in the form of a list, table, or diagram the types of adjustments which are possible in a given area and those which, in fact, are adopted at the time of the study.

Wherever there is discussion of desirability of public regulation of private land use as a means of coping with the hazard of extreme events a specific statement, possibly in the form of a scenario, should be made to show the probable public effects of permitting continued development of the hazard area.

Each statement of the plans for management of a coastal hazard area should include an estimate of the extent to which its continued occupation is likely to be affected by changes in a) population, b) technology, and c) risk tolerance.

In describing the range of possible adjustments to a natural hazard it is important to state the extent to which the adjustment may be expected to trigger changes in other adjustments, as where insurance may stimulate interest in a warning system.

Each statement of the choices which are available should include an estimate of the extent and type of loss aversion, in terms of human health and safety, property damages, and social surprise and disruption.

An explicit statement should also be made about the possibility that the means of coping with the hazard may protect or lead to the degradation of environmental features.

It is useful to prepare scenarios of the estimated impacts of the future occurrence of an extreme event under specified assumptions about the type of land use and the character of public activities prevailing at the time the event occurs.

An adequate set of impact estimates will a) describe the potential consequences of each adjustment alternative (including taking no action), b) describe impacts in terms of those outcomes which are most important, and c) reveal the probabilistic nature of the potential outcomes.

Any such discussion of natural hazards options should outline the major trade-offs which the community will experience in choosing one option over another, and should estimate the way in which the costs and benefits will be distributed among different age, ethnic and income groups in the community.

In presenting these choices it is useful to point out those options which would avoid or preclude irreversible changes.

3. Improving Citizen Participation

Wherever practicable a description of a vulnerable area should be linked with information about the availability of warning systems and with statements of the kinds of responses which people could make to the hazard when they recognize its full dimension and receive a warning.

Effort should be made to find out which channels of information about hazards have higher credibility in the view of the people for whom the information is designed, and those channels should be used for disseminating information about the hazard.

In preparing plans for dissemination of information it is important to find out what sectors of the population have experienced the extreme event in question, and to design the presentations so that the information will be intelligible to the newcomers.

4. Organization and Coordination

Descriptions of the proposed change in adjustments to hazards also should discuss the existence or creation of the necessary powers to promote the new work within state or local agencies.

Specific consideration should be given to ways in which planning for natural hazards in coastal areas can be linked with emergency planning for disasters under Section 201 of the Disaster Preparedness Act of 1974.

For each area vulnerable to extreme natural events in which economic development is in prospect a description of the hazard should be presented to the regional office of the Occupational Safety and Health Administration.

Wherever there is prospect of Federal investment in a flood plain the attention of the responsible Federal agency should be called to the provisions of Executive Order 11926 or its replacement.

Wherever there is the possibility of energy facility development within a coastal area an assessment of potential impact of extreme natural events should be made.

State Authorities and Opportunities

As presented in Section IV, the states have a wide variety of statutes and administrative procedures upon which to draw in dealing with natural hazards.

Section V provides references to much of the pertinent literature, and Section VI lists interested agencies.

The Appendices offer more details pertaining to legal implications and types of analysis.

The central opportunity for the state coastal zone management agencies is to find effective ways of applying to state programs for coastal areas the concepts, information, and analytical methods previously developed in natural hazard studies. To do so will reduce the vulnerability of the nation to catastrophe and will enhance the resilience of land and water uses along the coast.

SECTION II

MAJOR COASTAL HAZARDS

II. MAJOR COASTAL HAZARDS

Coastal areas are afflicted with a distinctive array of natural hazards. Beach erosion is unique in its problems, but in large sections of the coastline the use of coastal resources contends with risks from hurricane, tornado, flood, landslide, earthquake, tsunami, volcano, snow avalanche, or land subsidence.

A. A Framework for Hazard Analysis

In order to deal effectively with natural hazards, a coastal zone management plan should include the following five components: delineation of hazard areas, determination of present and future uses and possible losses, consideration of adjustments, choice of adjustment, and development of a catastrophe contingency plan.

Each of these steps may include certain implicit problems, for example:

1. The delineation of areas potentially affected by extreme natural events always is subject to differences resulting from the quality of scientific data and the methods used to analyze them. There can never be a completely accurate, precise description of what area is subject to what degree of risk. It is extremely difficult to estimate either the magnitude or the probability of the very rare event such as the great hurricane. This is because:

   Data usually are lacking on the precise extent and magnitude of past events;

   The historical record rarely exceeds 50-100 years;

   The methods for analysis and application of the statistics continually undergo refinement;

   The conditions in which the event occurs are affected by human factors such as urbanization, farm practices, and construction works.

However, any delineation may be revised in the light of new information or improved methods, and public designations of hazard areas should provide for such revision.

2. The human occupation of a vulnerable area always involves a use of a resource and a risk of possible loss. As outlined in Figure II-1, the interaction of social systems and natural systems leads to the creation of a resource and of a hazard. With rare exceptions, the resource yields benefits - the amenities of recreation, the economies of ocean shipping facilities, and the like - and at the same time, generates the inevitable cost of the damages - hurricane damage, loss of a beach, and the like - which will occur when an extreme event hits.

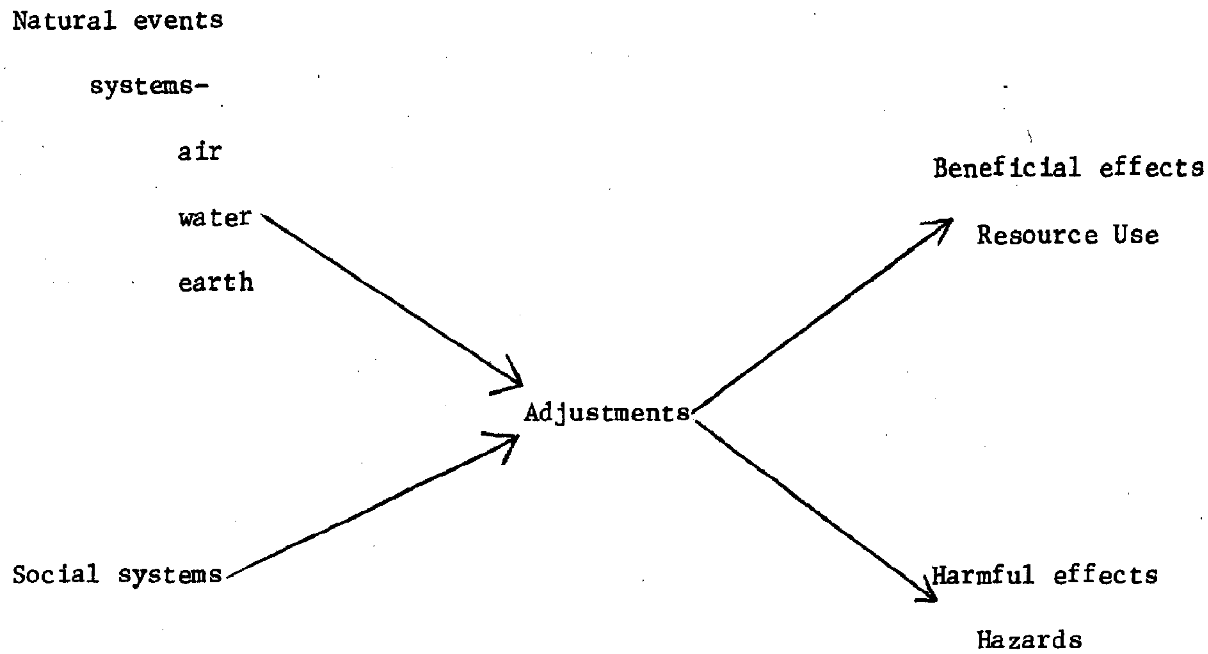


FIGURE II-1

THE INTERACTION OF SOCIAL AND NATURAL SYSTEMS

It is generally misleading to suggest that there are no social gains from occupying the coast. The problem is to find what tradeoff of resource use and hazard will be most beneficial to the community, state, and nation.

3. There is almost always a wide range of adjustments which can be made to a hazard: It is rare that only one course of action is worthy of consideration. The tendency is for people confronted with the hazard of an extreme storm, water height or earth movement to think of only a single kind of adjustment. They assess the practicability of building a protection work or of evacuating the area. However, usually there are a number of possible actions which deserve examination. These include:

A new or improved warning system, including preparedness plans to respond to a forecast when it is issued.

Control and protection works, such as groins, beach nourishment, and dams. Weather modification sometimes is suggested as a potential adjustment.

Design and construction of buildings so that they will resist wind, water or earthquake.

Management of land to minimize loss of property or life when the extreme event occurs. This includes land acquisition, zoning, subdivision regulations, building ordinances, and easements as tools for carrying out land use plans.

Insurance against the losses.

Relief and rehabilitation assistance for those suffering losses.

The most suitable adjustment should consider all possibilities, and may turn out to be a mix of several types rather than reliance on a single one.

4. What is chosen as an adjustment at one place and time may affect the hazard elsewhere or at a later time. Adopting an adjustment, such as a warning system or beach stabilization, does not necessarily minimize a hazard for all time. A beach protection program may worsen erosion down current; an improved warning system may encourage people to remain in an area where they will become subject to even greater losses as population grows and evacuation routes prove inadequate; zoning regulations may permit building to cluster along a "100-year" flood line where the greater, but less frequent flood may play havoc.

5. Reduction in exposure to more frequent events may build the potential for catastrophic losses from the very rare events. Where the hazard of loss from high probability events is reduced, as by building control works or strengthening buildings or purchasing insurance, the property may become especially vulnerable to the large event of probabilities of .005 or less. A catastrophe, involving profound dislocations from which the social system takes a long time to recover, may then result.

B. Hurricane

Characteristics of Hurricanes

Hurricanes develop from a variety of tropical weather disturbances and pass through several increasingly intense phases, classified as tropical depressions (with winds less than 40 mph), tropical storms (with winds between 40 and 73 mph), and finally, hurricanes (with winds over 73 mph).

The typical hurricane system has a diameter of about 300 miles, although winds of hurricane force are concentrated in a much smaller area. The air system in a hurricane in the northern hemisphere spirals counterclockwise toward the storm's low pressure center. The air absorbs heat and moisture from the warm ocean surface and gathers speed as it moves from higher to lower pressure. This heat and moisture constitute the hurricane's energy source, which is released again near the center where the converging air flows upward in a wall of clouds (the ring of strongest wind and rain). Inside the wall, in the hurricane eye, winds are much weaker, the heavy rains cease, and the sky may even be clear.

The forward movement of the hurricane system is relatively slow, usually around 15 mph in the lower latitudes. In general, although it is difficult to predict, the system moves with the speed and in the direction of the steering current, usually with some drift to the north. A northward drift will eventually carry most storms to higher latitudes where they tend to recurve and enter the midlatitude westerlies. Movement of a hurricane over land or into regions of cooler sea surface temperatures reduces the primary source of energy, and the intensity of the storm decreases.

Components - Wind is the element most commonly associated with hurricanes by the public. Highest wind speeds occur in a narrow ring usually extending 20-30 miles from the center of the hurricane. The highest measured wind speed was 197 mph in Inez (Colon, 1966), but gusts of 220 mph have been estimated from damages and barometric pressure records. In a major hurricane, gusts between 73 and 120 mph may extend 40-100 miles from the center.

Minor damages begin with winds of approximately 50 mph. Moderate damages, such as broken windows and displaced shingles begin with winds of around 80 mph, and major structural destruction begins when wind speeds reach 100 mph (Friedman, 1971).

About 90% of the deaths near the coast which result from hurricanes are caused not by wind, but by storm surge, the rise of water above mean sea level. The height of storm surge along the open coast depends on a number of factors which include wind speed, depth of water, storm trajectory, and speed of the storm. Coastal configuration can result in a funneling effect, and coincidence with normal astronomical tide will also affect surge height. Although the maximum surge usually affects only a short length of coastline, combined storm surge and wave action may have damaging effects over 100 miles away in either direction.

Heavy rainfall often accompanies hurricanes and can result in severe inland flooding. The amount of rainfall depends on many factors, however, including forward speed of the storm and topography.

Wind-driven waves on top of the storm surge pose a number of problems. First of all, the wave run-up can flood areas not reached by the surge itself. Second, the battering action of waves can transmit tremendous force. Third, the erosive power of waves is considerable.

The hurricane system usually generates a number of tornadoes in the right front quadrant of the storm as it approaches landfall and moves inland. The average length and width of hurricane-induced tornado paths is only half that of non-hurricane tornadoes, although they are still powerful storms.

A note on the tornado hazard is appropriate at this point. Although tornadoes are generally not a major problem in coastal areas except when associated with hurricanes, they are not totally inconsequential. In the past, there have been very damaging events in the Great Lakes area and increasing development and population is resulting in greater susceptibility.

The destructive power of tornadoes lies primarily in their high wind velocities and sudden changes of pressure. However, since they are usually associated with storm systems, they are often accompanied by hail, torrential rain and severe lightning (Brinkmann, 1975). Nationally, the loss of lives from tornadoes is high relative to other hazards such as floods or hurricanes. Like other natural disasters the social consequences are also disruptive.

Saffir and Simpson have devised a five category scale of hurricane intensity which is being used increasingly to describe hurricanes. It gives a general indication of both wind speed and storm surge height (see Table II-1). Figure II-2 represents the complete hurricane hazard damage system, with the components discussed above depicted on the left side of the flow chart.

Areas At Risk - No segment of the Gulf and Atlantic coasts of the U.S. is without vulnerability to hurricanes, but some areas have a history of more frequent hurricane occurrence than others. Parts of Texas, Louisiana, Florida, and (to a lesser extent) North Carolina have been especially susceptible. (Figure II-3 depicts annual probabilities of two magnitudes of hurricanes for the entire Gulf and Atlantic coasts.)

Precise estimates of storm surge heights with various probabilities are currently being calculated for all coastal communities participating in the National Flood Insurance Program. Figure II-4 displays some generalized estimates from Texas through North Carolina.

Temporal Variations - Hurricanes usually occur during the months of August, September, and October, with the season beginning in June and ending in November. There is also some evidence for longer term temporal

TABLE II-1

SAFFIR/SIMPSON HURRICANE SCALE RANGES

Scale Number (Category)	Central Pressure		Winds (Mph)	Surge (Ft.)	Damage
	Millibars	Inches			
1	$\geq$ 980	$\geq$ 28.94	74 - 95	4 - 5	Minimal
2	965 - 979	28.50 - 28.91	96 - 110	6 - 8	Moderate
3	945 - 964	27.91 - 28.47	111 - 130	9 - 12	Extensive
4	920 - 944	27.17 - 27.88	131 - 155	13 - 18	Extreme
5	< 920	< 27.17	> 155	> 18	Catastrophic

(Herbert and Taylor, 1975)

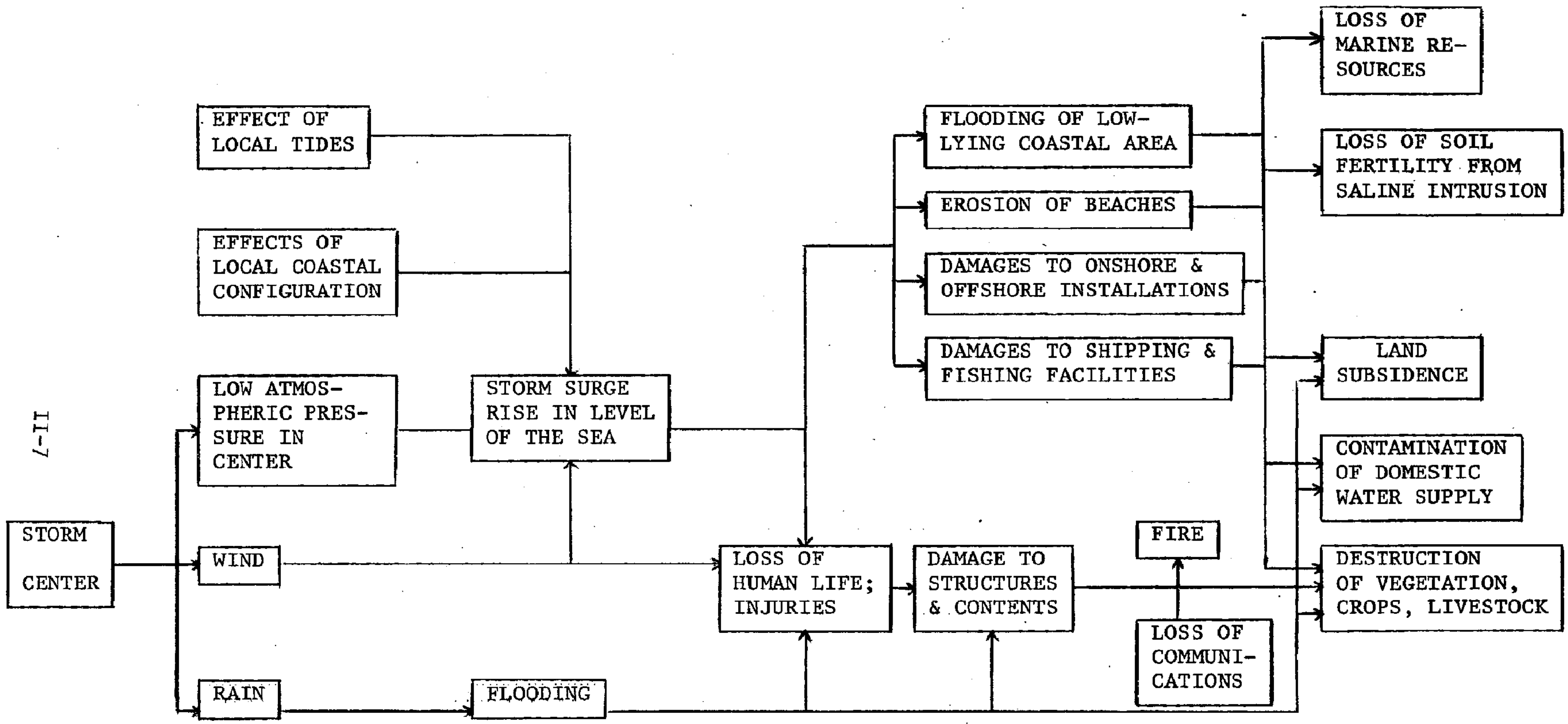


FIGURE II-2

TYPES OF POTENTIAL DAMAGE FROM TROPICAL CYCLONES. (FROM WHITE, 1974)

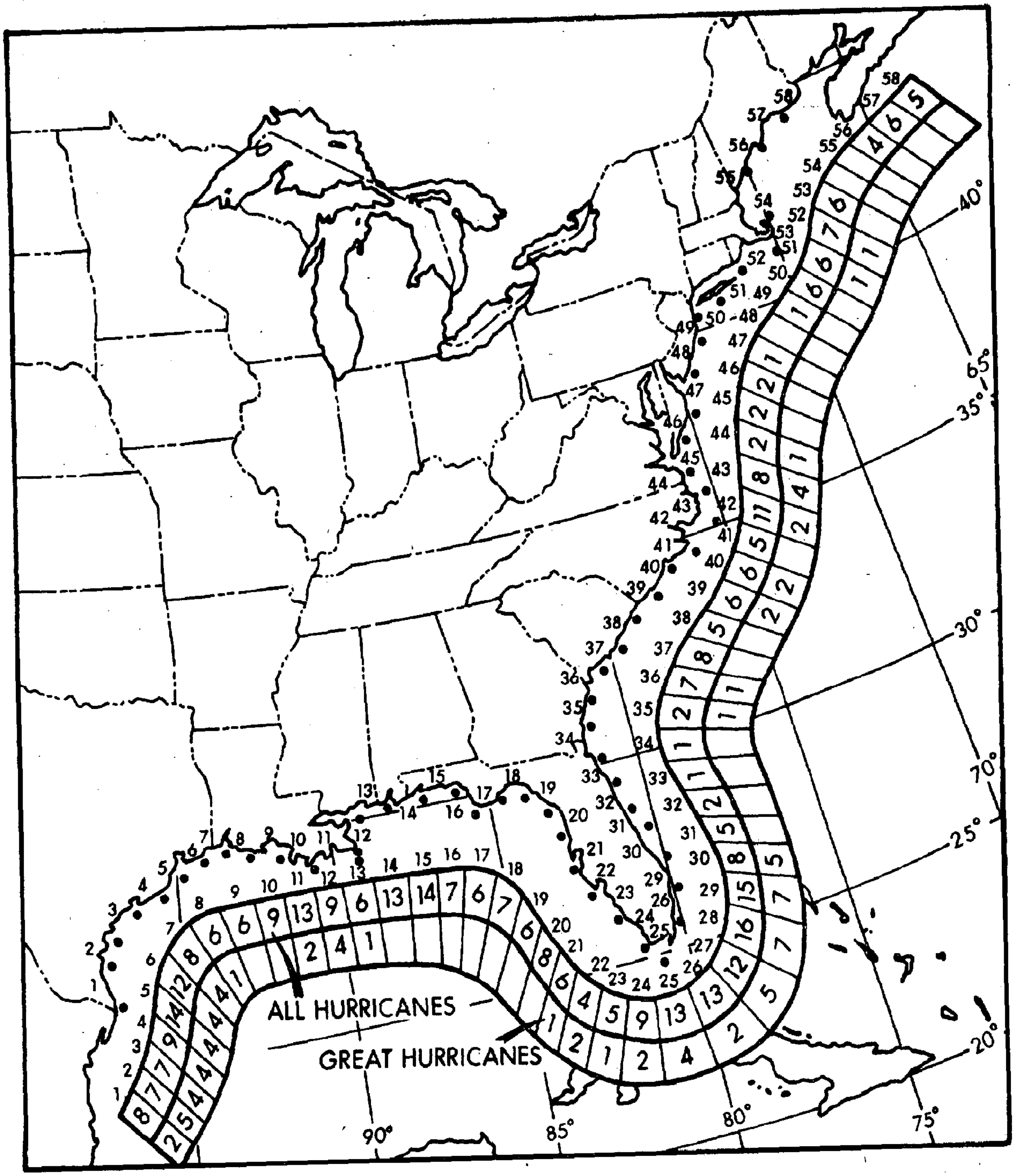


FIGURE II-3
HURRICANE PROBABILITY MAP

PROBABILITY (PERCENTAGE) THAT A HURRICANE (WINDS EXCEEDING 73 mph) OR GREAT HURRICANE (WINDS IN EXCESS OF 125 mph) WILL OCCUR IN ANY ONE YEAR IN A 50-MILE SEGMENT OF THE UNITED STATES COASTLINE (after Simpson and Lawrence, 1971)

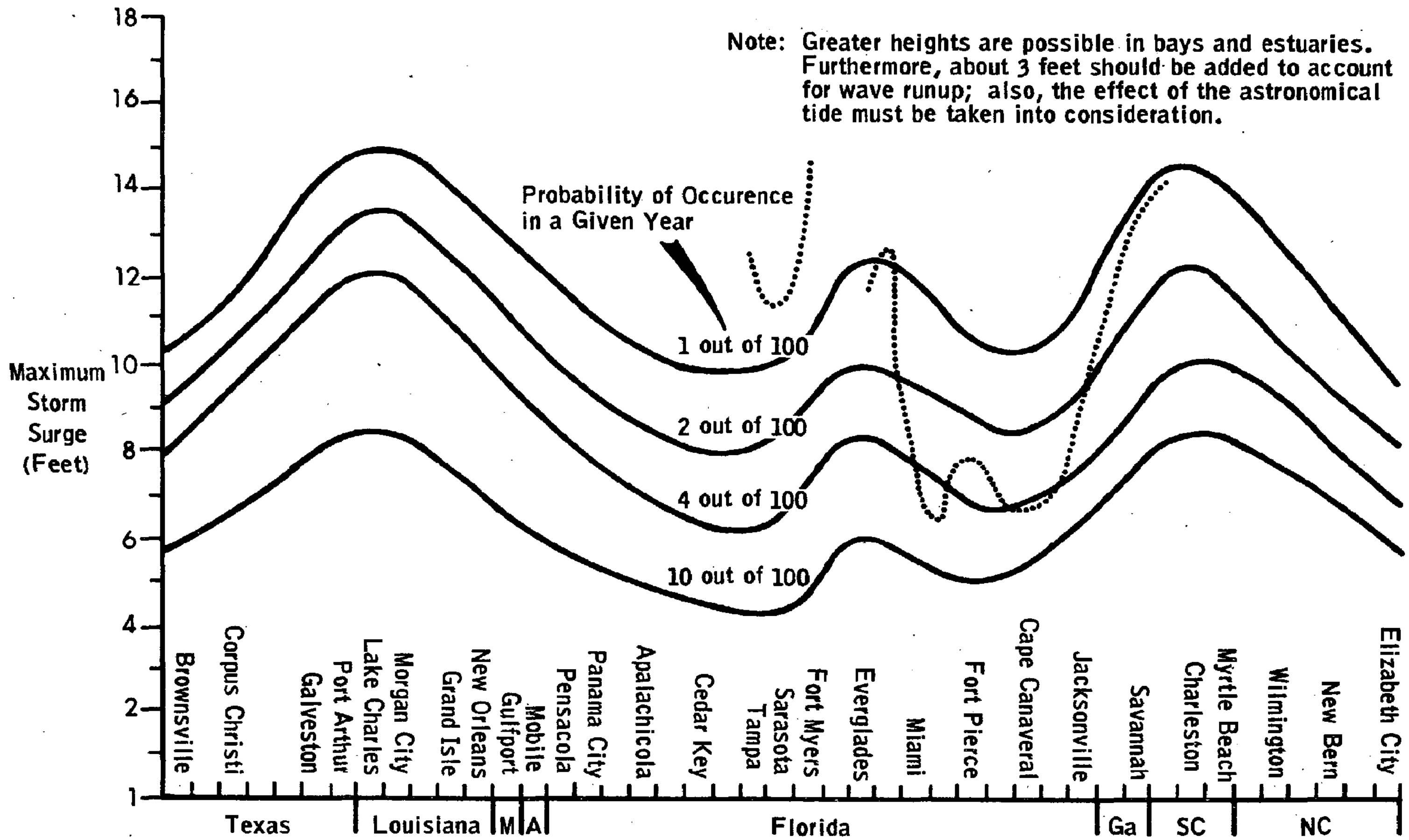


FIGURE II-4

COMPOSITE ESTIMATES OF EXPECTED SURGE HEIGHT[1]

[1] Solid lines based on U.S. Army Corps of Engineers and University of Florida probability estimates of annual occurrence of a storm surge on an open beach area (Friedman, 1971); dotted lines based on National Oceanic and Atmospheric Administration (1971a, 1972a, 1973, 1973a), probability of occurence is 1 out of 100.

variation in where hurricanes occur. In recent years the occurrence of major hurricanes has been concentrated in the Gulf region from northwest Florida to Texas. But in the 1950's there seemed to be a concentration along the Atlantic coast north of Florida, and during the 1940's the Florida peninsula experienced more hurricanes than it has in a comparable period since that time.

In 1976 forecasters at the National Hurricane Center in Miami, noted a tendency for hurricanes to develop in the Pacific Ocean and to hit the West and western Gulf coasts. The jetstream, a current of fast-moving air that flows around the world at high altitudes, has meandered south of its usual course, creating a "high-altitude vacuum" (Clark, 1976). This vacuum, in turn, is responsible for causing unusual storm conditions. Ocean storms tend to move toward the north and east to fill the vacuum. These conditions resulted in three hurricanes during 1976 along the California and Mexico coasts causing thousands of deaths and extensive property damage. In a similar manner, the jet stream has forced Atlantic hurricanes to move north and east away from the eastern U.S. mainland where, historically, they have most frequently occurred (see figure II-3).

Population at Risk - According to Friedman (1972) over 6,000,000 people are currently exposed to hurricane storm surge, with a substantial portion concentrated in the Gulf region. Table II-2 lists the population-at-risk in six graduated storm surge exposure zones for the entire Gulf and Atlantic Coasts. Table II-3 gives the population-at-risk in four wind exposure zones.

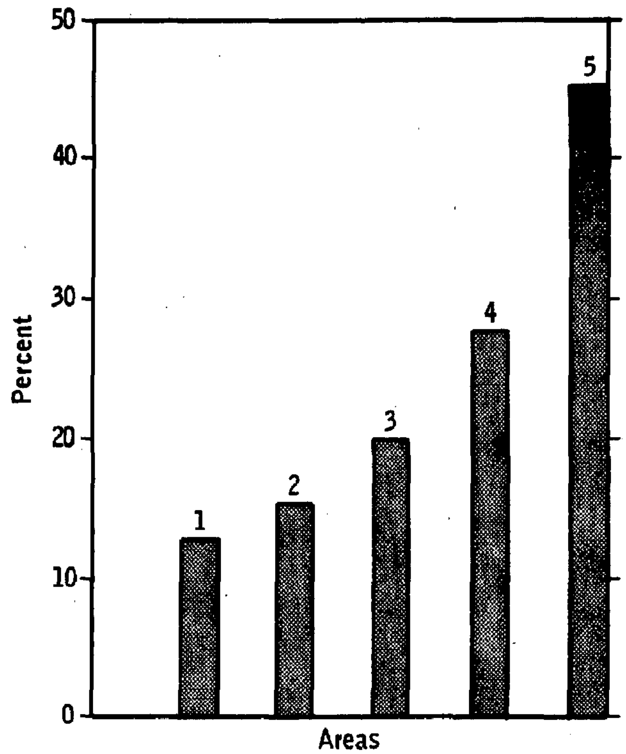
Coastal population is growing three or four times as fast as the national average. Figure II-5 illustrates that higher rates of population growth are found closer to the coastline. A correlated concern is that many of these new coastal residents have never had experience with major hurricanes. As much as 77.5% of the residents in coastal counties have not experienced a major hurricane, and in the coastal counties of some states, virtually no one has had such experience (Herbert and Taylor, 1975). Adding to the problem is the likelihood that many inexperienced residents incorrectly believe they are experienced.

Effects of Hurricanes - The two dramatic effects of hurricanes are fatalities and property damage. Figure II-6 illustrates a general trend toward fewer deaths from hurricanes since the turn of the century. Since 1940, however, the average annual hurricane fatality figure has more or less stabilized. As recently as 1957 over 400 deaths resulted from a single hurricane in the sparsely populated but low-lying area of Cameron Parish, Louisiana.

The main reason for the reduction and stabilization in death rate has been improvements in adjustment to the hazard, especially a much better warning system. The potential still exists for catastrophes such as the thousand-plus disasters of the past. As population continues to grow in coastal areas, and as more reliance is placed on structural and technological protection, the possibility of catastrophic losses grows steadily.

FIGURE II-5

PERCENT CHANGE IN POPULATION: 1960–1970



KEY

1 United States

Atlantic and Gulf coasts:

2 Coastal States

3 Coastal Counties

4 Coastal County subdivisions

5 Coastal County subdivisions excluding any which extend more than one mile inland.

(U.S. Bureau of the Census, 1961; 1971)

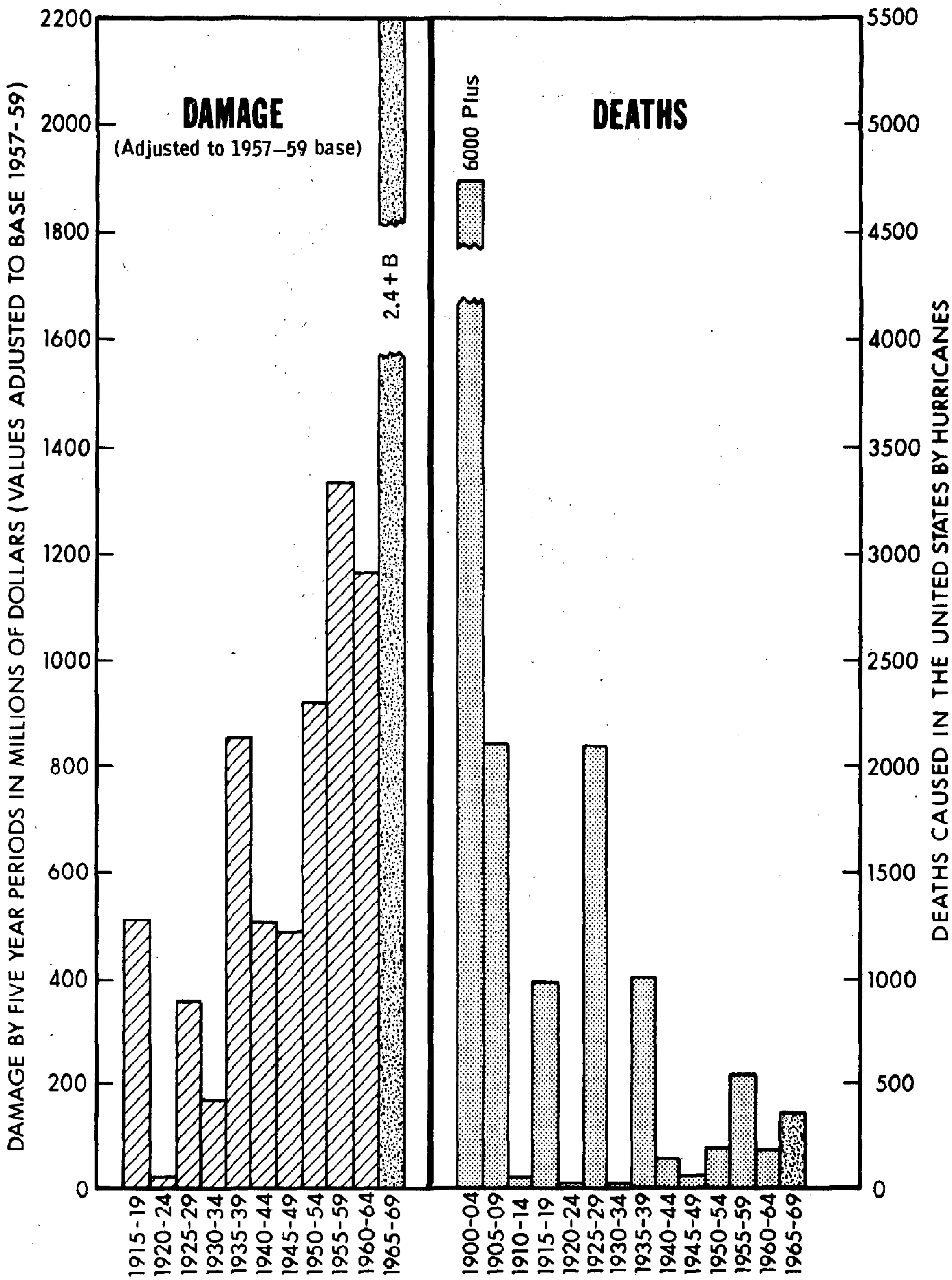


FIGURE II-6
DEATHS AND DAMAGES FROM HURRICANES IN THE UNITED STATES
(National Oceanic and Atmospheric Administration, 1972)

TABLE II-2

ESTIMATED POPULATION-AT-RISK/STORM SURGE

(Friedman, 1972)

Storm Surge Hazard Zone	Return Period	Population-at-Risk
A	less than 5 years	30,000
B	5-10 years	130,000
C	10-25 years	2,550,000
D	25-50 years	1,780,000
E	50-100 years	1,500,000
F	more than 100 years	610,000
TOTAL:	Zones A through F	6,600,000

TABLE II-3

ESTIMATED POPULATION-AT-RISK/HURRICANE WIND

(Friedman, 1972)

Hurricane Wind Hazard Zone	At least one occurrence in past 80 years in county-sized area of peak gust	Population-at-Risk
A	125 mph or more	14,550,000
B	100 to 124 mph	37,230,000
C	75 to 99 mph	23,770,000
D	50 to 74 mph	20,490,000
TOTAL:	Zones A through D	96,490,000

While loss of life has decreased dramatically since 1900, property damages have increased exponentially during the same period. Figure II-6 also depicts that trend. Property damages stem mainly from storm surge flooding, but also from erosion beneath structures built too closely to the water, and from wind, which can affect a very large area. Average loss per hurricane is approximately half a billion dollars, but could range from $4 million to $4 billion (Sugg, 1967).

There are also other effects such as social and economic disruption, injury, psychological trauma, water supply contamination (with accompanying health hazard), soil infertility, and shoreline changes. These and others have been integrated into Figure II-2.

Adjustments to the Hazard

Hurricane Modification - Cloud seeding of hurricanes with frozen nuclei, such as silver iodide, was conducted as early as 1947 under Project Cirrus. The theory, according to Simpson, is that seeding the clouds of the eye wall would start a chain of events, with a reduction in maximum winds as the net result. Other approaches suggest seeding outward from the eye wall, thus short circuiting the inflow to the eye wall and diverting energy from the core.

Relatively few hurricanes have actually been seeded, and the results of those experiments are subject to various interpretations. Certain fluctuations in wind speed occur naturally during the life of a hurricane, and it is difficult to ascertain whether reductions after seeding are natural or artificial. There is some evidence that reduction of maximum winds is on the order of 10 to 15% (Rosenthal, 1971). Advocates of seeding point out that such a reduction could prevent millions of dollars in property damage. Other observers point out that very little is actually known about the effects of seeding and that the process may have such undesirable consequences as an increase in the area of damaging storm surge, or a decrease in rainfall, or the diversion of the storm from its normal path. More research and investigation is needed to resolve these differing opinions.

Structural Protection - Artificial means such as seawalls, bulkheads, and revetments are designed to prevent the passage of waves and storm surge. Since 1955 the Corps of Engineers has conducted well over a hundred hurricane and shoreline protection studies. In over half of those, structural protection was advised by the Corps as being economically justified, and most of those projects were authorized. Costs range from $100 to $400 per foot of shoreline protected (U.S. Army Corps of Engineers, 1971), and up to seventy per cent (70%) of the costs for protection of non-federal public land are met by the Federal government. About sixty-eight per cent (68%) of the coast is privately owned and ineligible for Federally subsidized protection.

Some opponents to protective structures object on the grounds that the works are inhibiting natural processes and thereby can cause ecological destruction and may even increase some types of damage. For example, seawalls can modify wave action so that the ocean bottom profile steepens and reduces beach width (Pilkey, Pilkey, and Turner, 1975).

> A further objection is that such structures encourage increased occupation of the hazard zone, and that when the structure fails or is overtopped, as will happen eventually, losses may be greater than if the structure had not been built.

<u>Assistance to Natural Protection</u> - Sand dunes and beaches serve as buffers against coastal storms. In some places dunes and beaches have been built artifically. In others, the natural protection has been supplemented with additional sand, and in still other cases, steps have been taken simply to stabilize and protect the natural features.

> The protection from major storms afforded by such features is dubious, however. Grassy dunes ten to twenty feet high have been completely obliterated by hurricanes (Carney and Hardy, 1967). In actively eroding areas of beach, the artificial or renourished features must be continually maintained.

<u>Warning Systems</u> - The hurricane warning system consists of three main stages: evaluation (detection, measurement, collation, forecast); dissemination (decision to warn, message content, distribution of message); and response (interpretation of message and resultant behavior) (Mileti, 1975). Hurricane forecasting for the Atlantic and Gulf coasts is primarily the responsibility of the National Hurricane Center in Miami, Florida. There are essentially four elements to the forecast: 1) landfall location, 2) time of landfall, 3) storm surge height, and 4) wind speed. Currently the "24-hour landfall error" is approximately 100 miles. That is, twenty-four hours before landfall, the NHC can predict landfall location within 100 miles. However, it is well known that hurricanes can execute intricate shaped trajectories which make landfall prediction quite difficult. There is debate about how much improvement in forecasting is likely to occur during the next decade.

The forecasts (in the form of Bulletins and Advisories) are disseminated to the broadcast news media by regional Hurricane Warning Officers through the NOAA National Weather Wire, a special circuit, which connects NWS officers, private users and the news media. The message usually reaches the local level through the NWS office (which may also issue Local Action Statements), Civil Defense (NAWAS communications net), Federal Aviation Administration, or armed forces communications system. It is then dispersed principally by radio and television to the public.

> Response to warnings is extremely variable both within and between communities. It appears that communities with recent disasters are more likely to evacuate than other places. However, due to scarcity of research it is difficult to predict who will leave and who will not (Wilkinson and Ross, 1970; Baker, Brigham, Paredes, and Smith, 1976).

It is clear that complete evacuation would be unlikely or impossible from some areas with high concentrations of people and limited access routes. Miami and New Orleans have devised "vertical" evacuation plans in which multi-story buildings would be used as temporary shelters. However, this should not be used as a basis for encouraging a policy of high rise construction. A wiser strategy would be one which avoids the need to evacuate more people than would be possible. Sanibel, Florida, an island community with only one causeway to the densely populated mainland, has adopted a population density ceiling.

> The evacuation difficulty increases the likelihood of catastrophe in some coastal areas which are permitting unbridled development.

Land Use Management - The notion of land use management is to utilize hazardous areas in ways which will minimize uneconomic risk of losses to property and life.

> Were all individual property owners to be fully informed of the risk of hurricane damage, they might well make some accommodations in their choice of building location and design. They commonly calculate their risk for their expected tenure of the property and lack direct incentives to avoid investment which will induce damage to others or will incur public expenditures for protection, relief and rehabilitation.

Land use management of the type mentioned above is usually accomplished through governmental regulation.

Zoning specifies a zone or zones in which certain uses are prescribed and others prohibited. This is the technique by which most communities have complied with National Flood Insurance Administration regulations (by requiring new structures to be elevated or floodproofed to the level of the one per cent (1%) probability storm surge). Some localities have gone further. Warrick, Rhode Island has two zones. In the one per cent (1%) probability zone, the restrictions described above apply, but in a smaller, more hazardous zone, only non-commercial boat docks, beach cabanas, and open space uses are allowed.

Building codes, also usually enacted at the local level, can require that structures built in a hazard-prone area be constructed to withstand minimum intensities of storm surge, wave action and wind. Some communities have met FIA requirements through this medium. Model building codes specifically designed for hurricanes were developed and adopted by places in South Florida and Mississippi. Some places, like Portsmouth, Va., prohibit the subdivision of land if it would be unsuitable for intended use due to flooding or other hazards, unless said hazards are overcome (e.g. by filling or construction).

Texas recently drafted a model building code which employs the concept of graduated hazard element zones. The most severe of the four zones would be subject to storm surge, wave battering, wave scour, and wind. The least severe would be subject only to wind. When a developer subdivides land into lots for residential, commercial, or industrial uses and sale, he must usually satisfy requirements imposed by the state or the community.

A zone at the shoreline can be delineated based on a number of variables, (e.g. one per cent (1%) probability storm surge, specific contour levels, etc.). Construction within a zone can be controlled or prohibited by establishing set-back lines. A unique aspect of this strategy is that it often combines ecological, as well as natural hazard considerations. Set-back lines have been enacted at both the local and state levels.

In recognition of the protective value of beaches and dunes, some states and local governments have enacted laws to preserve these features, but stop short of set-back lines. In practice, many of these laws are difficult to enforce because the public fears the loss of open beach rights. However, Palm Beach, Florida restricts construction and activities in the area of sand dunes.

Mobile homes are easily overturned and "relocated" by strong winds. To prevent this, some laws require that the homes be anchored to withstand certain wind loads. North Carolina has accomplished this through the state building code, while Florida has a special vehicle safety law.

Section 280.305 of the <u>Mobile Home Construction & Safety Standards Act</u> of 1974 (Title VI of Pl. 93-383, U.S.C. 5401 et seq.) establishes structural design requirements which must be met in order for mobile homes to obtain designation as "Hurricane Resistive". Mobile homes must be designed to withstand horizontal wind loads not less than 25 psf and a net uplift not less than 15 psf. For exposures in coastal areas, HUD may establish more stringent requirements. (Federal Register, Vol. 40, No. 244, Dec. 18, 1975.)

<u>Federal Aid</u> - Insurance coverage against wind damage has long been available through home owner's policies. Since 1968 communities have had the opportunity to make coverage against storm surge and wave action available to residents by enacting land use controls in the one per cent (1%) probability storm surge zone. The National Flood Insurance Act made flood insurance available in communities which agreed to require structures to be elevated or floodproofed to the level of the one per cent (1%) probability storm surge (or other flood source). The Flood Disaster Protection Act of 1973 prohibits the use of federal funds for construction in, or acquisition of flood-prone land, and prohibits loans from federally insured banks and loan institutions for construction in such areas unless the community is participating in the National Flood Insurance program. The Disaster Relief Act of 1974 provides for sanctions against communities not insuring public structures.

Relief (emergency services immediately following a disaster) and rehabilitation (longer-term activities to restore a stricken community to well-being) involve a plethora of Federal, state, and local agencies and private organizations.

For a detailed discussion see Mileti (1975). The law under which the nation now operates is the Disaster Relief Act of 1974 (PL 93-288).

Experiences

Several states, including Georgia, Maryland, Maine, Massashusetts, New Jersey, New York, Rhode Island, and Virginia, have recognized the value of coastal wetlands, marshlands, tidelands, and estuaries, and have attempted to protect such areas by regulating their development through a variety of laws. Most of the legislation is oriented toward ecological preservation and protection, and thereby incidentally, excludes intensive, loss-prone activities. Others, such as Massachusetts, deal explicitly with the hazard problem by reviewing any proposal which alters land subject to tidal action, coastal storm flowage, or flooding.

C. Flood

Delineating the Hazard

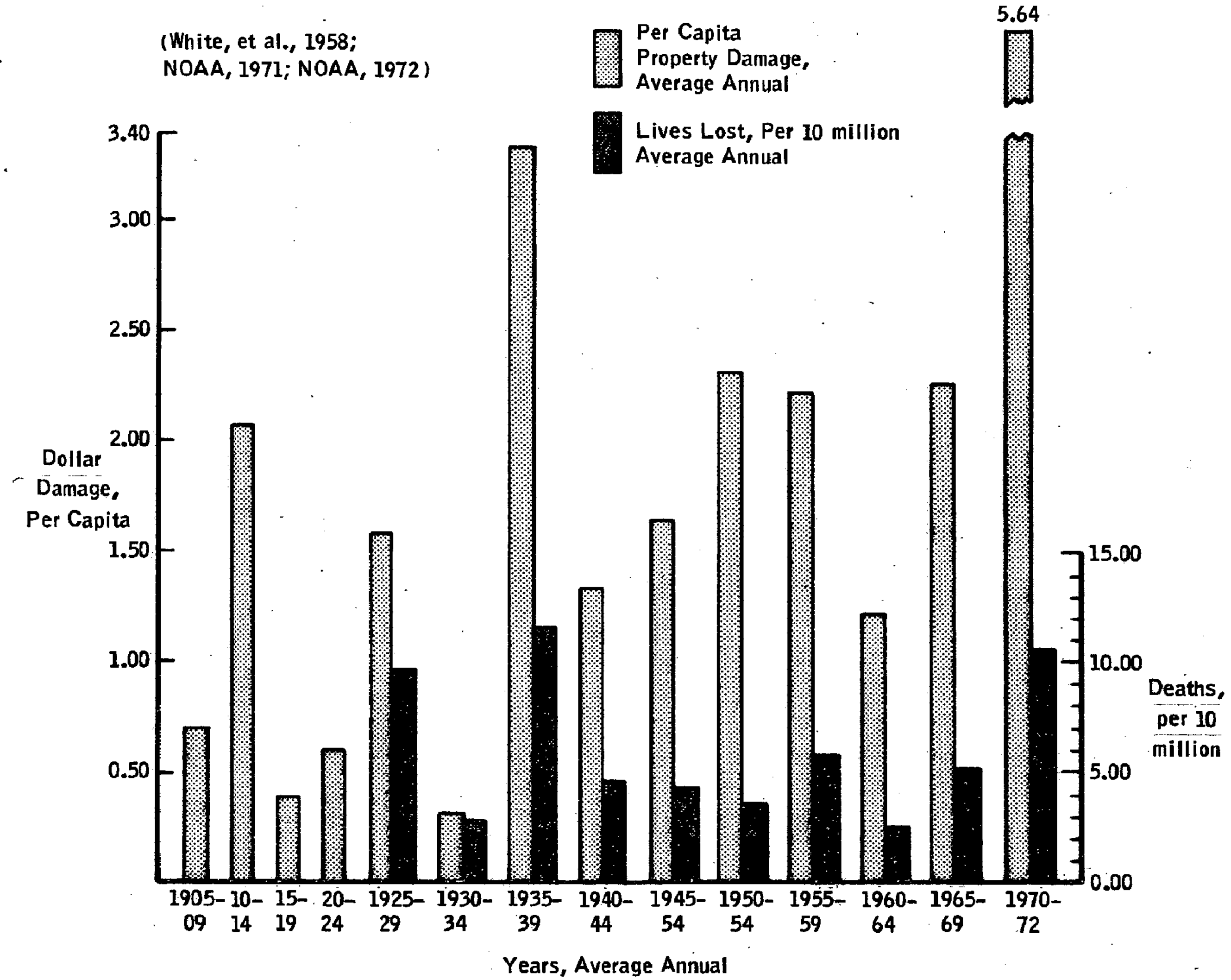
Every coastal state experiences flood losses. Measured by absolute area, the large majority of lands in flood plains are in the south Atlantic and Gulf states. Smaller reaches of streams draining into the Great Lakes, New England and Pacific coasts are subject to overflow from peak discharge. Areas subject to flooding are increasing because of several land use changes. Enlarging the area of land covered with impermeable highways, roofs and parking lots has accelerated the runoff from urban areas. Increasing erosion of farm and grazing lands has raised the level of channels and the cross-section area flooded.

For the country as a whole, the major populations affected by floods are in the Northeast, Ohio basin, Great Lakes and California water resources regions. Within the coastal zone, the more vulnerable urban places are along the North Atlantic and Gulf coasts, although along the Gulf, flooding does not present a major problem except when associated with hurricanes or offshore storms.

The National Weather Service, one Federal agency with records on nationwide flood losses, has documented a persistent upward trend in total property losses, although per capita loss has remained fairly constant (Figure II-7). By 1970, the accepted average annual loss figure was $1 billion. Because of difficulty in collection and differences in methods and numbers of years for which data was collected from various government agencies, this estimate

FIGURE II-7

LOSSES IN UNITED STATES FLOODS 1905–1972



Damage figures in standard U.S. $, adjusted to base 1957–59 –100 may be considered low. The Office of Emergency Preparedness in 1972 placed the loss figure at $2 billion annually. However, only a small proportion is in coastal reaches such as the Mississippi delta.

There appears to be no clear relationship between property damage and number of fatalities. Flood related deaths are at a slow increase or stationary, between 2.5 and 5.8 per 10 million population, with the exception of three five-year periods, according to NWS data.

Flood control and protections works have lowered the level of damage from the more frequent floods; however, they have increased the potential for great catastrophes. Dams and levees have historically encouraged the increased occupation of the "protected" area and consequently have increased the possibility of heavy property and human losses and broad social disruption when a flood larger than the design flood occurs. For example, much substantive damage in and near northern coastal states during Tropical Storm Agnes was behind levees and flood walls.

On the individual level, the loss of personal possessions and economic security, as well as the death or injury of friends, may result in psychological depression and anxiety. The flood event disrupts families by altering economic security. On the other hand, floods may provide an impetus for commercial development and construction of housing units outside the flood plain. Flooding may cause temporary or permanent disintegration or reduction in the effectiveness of organizations. These conditions may provide opportunities for internal change and improvements within a community. The most serious effects of flooding may be felt at the community level. Public buildings, schools and services are often damaged. Destruction of private property diminishes the local tax base. This may be compensated partially by increased city sales during the reconstruction.

Adjustments To The Hazard

Control and Protection Works - Numerous governmental and quasi-governmental agencies are involved in the construction of dams and reservoirs, levees, channel improvements, floodways, and in the utilization of other structural works and land treatment measures to inhibit water runoff. Mean annual construction expenditures for single-purpose flood control structures, i.e. omitting the much larger multipurpose projects, by the U.S. Army Corps of Engineers, have been approximately $100 million for the last decade. Flood damages averted by flood control works are estimated at $1 billion annually.

These control works, however, are effective only up to the project design levels. According to some estimates, (e.g. Holmes, 1961), damages occurring from overtopping, failure of works, or an incomplete structure may account for 33-40% of total flood losses, and occur in one-third of the total years.

Major constraints to building these types of control works are the large capital expenditures by federal and state agencies, and local opposition to new engineering works because of their environmental impacts.

Warning Systems - The preparation of official river stage forecasts and the issuance of public warning for floods is the responsibility of the National Weather Service (NWS) of NOAA. Twelve River Forecast Centers and the second level River District Offices serve approximately ninety-seven per cent (97%) of the country, including Alaska.

In the communication of warnings, floods are divided into two types: "floods" which develop and crest over a period of six hours or more, and "flash floods" which develop and crest more quickly. The latter rarely occur in the coastal zone section of streams. Forecasts and warnings are transmitted over NOAA National Weather Wire Service, and the NOAA VHF/FM Radio Transmission Service to organizations in the thirty-six states with receiving equipment. Other areas and states are notified by telephone or telegraph.

As with other hazards, the response to flood warnings varies greatly and is not well understood. If warnings are to serve their purpose, it is essential to anticipate the kinds of individual and organizational action which can and will be taken.

Flood Proofing - Alterations in design and construction of structures can greatly decrease susceptibility to flood damage. A recent Corps of Engineers handbook (1972) lists seven flood-proofing measures: 1) installation of watertight windows and door closures; 2) provision for moving damageable contents to higher levels; 3) provision for emergency operation of electricity, water, and sanitary services; 4) sealing of walls and foundations against seepage; 5) strengthening of walls to resist hydrostatic pressure loads; 6) installation of drain sumps and pumps; and 7) elevation of structures on open columns.

Conditions which inhibit the adoption of flood proofing techniques are: the high monetary costs of floodproofing large old structures as well as small residential structures; the lack of technical knowledge by architects; the lack of public encouragement through tax deductions, information or other means; and finally the reluctance of property owners to acknowledge the infrequent hazard and make visible changes in their structures.

Care should be taken so that the adoption of flood-proofing techniques do not induce a false sense of security and thereby encourage owners to expose themselves unwittingly to catastrophic events exceeding the limits of the structure.

Land Use Management - Land management techniques can help lessen the impact of flood by 1) reducing the population and economic investment at risk; 2) reducing the public cost of subsequent evacuation, relief and rehabilitation, and 3) decreasing dependence upon costly protection works requiring public investment. Although flood plain land use management techniques may be the adjustments most likely to reduce national flood losses, adoption has been slow.

One difficulty has been in calculating the full social costs and benefits, especially estimating the value of foregone economic development. This is coupled with a strong sentiment in some communities against governmental interference in the use of land.

> In those communities that have passed land use regulations, factors that assisted the early adoption include: availability of flood plain information, recent flood experience, vigorous state support for a strong local planning authority, strong local leadership, and an environmentally conscious citizenry.

Federal initiatives have helped to provide direction and to encourage wise use of flood plains. Executive Order #11296 of 1966 (see Section III) discourages the location of federally supported building on flood plains, but it has been slow in implementation and lax on supervision. Incentives to land use management accompanied the Flood Insurance Act of 1968, by requiring the adoption of community flood plain regulation for eligibility in all phases of the insurance program.

Flood Insurance - Through the National Flood Insurance Act of 1968, subsidized insurance is available to residents of participating communites that have adopted and are enforcing flood plain land use management measures that modify the flood loss susceptibility. FIA supports delineation of flood hazard areas and estimates the actuarial and subsidized premiums.

The rate of individual purchase of flood insurance has been increasing.

> Common explanations for failure to purchase insurance revolve around ideas that individuals are unaware of its availability and costs, that they have little incentive to purchase insurance if relief and loans are readily available after floods, the homeowners' perception of risk, and psychological barriers.

Relief and Rehabilitation - Relief and rehabilitation are available under three categories of flood impact: national disasters declared by the President; national disasters declared by either the Small Business Administration or the Farmer's Home Administration; and floods in which no declaration of disasters are made.

At the request of the governor of an affected state, the President may declare a national disaster if necessary relief exceeds the resources of the state. Loans, temporary housing and restoration of public facilities can then be made available. In a ten year period, approximately twenty-two per cent (22%) of all major disaster declarations were for floods, amounting to seven per cent (7%) of all allocations from the President's disaster fund. Some other types of disasters, especially severe storms along coastal states, may be closely associated with flooding and can be included in this category.

> When a Presidential declaration is not made, department heads of various federal agencies, such as the Small Business Administration (SBA) or the Farmer's Home Administration (FHA), may issue loans to individuals and small businesses or provide other aid to agriculture areas.
>
> When a flood event is not declared a disaster and these types of the federal aid are not provided, individuals must bear the loss. Volunteer relief organizations, in addition to the Red Cross, assist whether or not a disaster is declared.

The Federal government has helped to relieve some of the financial burdens of these volunteer groups. The Red Cross provides aid through the cleaning, building and repairing of homes and household furnishings. The Federal government augments this by its continuing urban renewal programs and by paying for household accessories for those going into publically-provided housing. The U.S. Department of Agriculture issued $9 million worth of food stamps to Tropical Storm Agnes victims, a savings of that amount to the Red Cross. All of these measures ultimately lead to an increased burden which must be borne by individual taxpayers.

Trends

In most communities, more than one adjustment to flood is employed. Although difficult to document, there seem to be four main combinations of adjustments within urban flood plain areas. Heavily relied on is loss-bearing by individuals, supplemented with public relief and rehabilitation and the availability of insurance. In a second combination, public entities, in order to qualify for continued flood insurance adopt a program of land management. Third, flood proofing and community preparedness plans are built on adequate warning systems. A fourth common set of adjustments is the combination of control and protection works with relief and rehabilitation assistance when the works provide inadequate protection.

Another trend is the increasing encroachment upon flood-prone lands. Although no direct correlation has been found between the degree of protection and the rate of flood zone growth, it is likely that flood protection works, along with highway construction, provide a stimulus for further flood plain invasion. The nation has attained a position in which it suffers large annual losses from occupying its flood plain, while reaping benefits from the use of those lands. Any change in land use would either increase or decrease net benefits.

National Forces

At least three trends underway at the national level may change the current types and mixes of adjustments to floods:

Population Shifts - Reduction in the number of farms and the increase in farm size has reduced rural population in flood plains. At the same time, the enlarged urban employment is accompanied by the invasion of suburban and exurban families into former agricultural areas. This growth has resulted in extensive residential, commercial and industrial development in unfamiliar low-lying areas.

Consumers and Workers - One trend that may highlight awareness of risk potential, and thus reduce damage potential, is the movement to protect workers and consumers. Through its activities to protect workers from undue risks, the Occupational Safety and Health Administration (OSHA) may help to restrict manufacturing and commercial employers from locating in flood vulnerable areas. Many Federal and state agencies seek to prevent purchasers from being victimized or exposed to unforeseen risks. Along these lines, control of house design and location, especially mobile home property and new subdivision development may be advantageous.

Citizen Participation - Increased citizen participation in decision-making has had a dramatic effect on blocking the construction of flood control works. Emphasis on the preservation of wildlife and aquatic habitat and the maintenance of open space in urban areas has curbed the construction of new structures and helped to promote nonstructural measures of reducing or controlling flood losses.

Federal Aid and Guidelines

Federal emphasis on certain adjustments has changed markedly over the past 20 years. Greater attention has been given to relief and rehabilitation and to insurance and less to control and protection works. Expenditures moved dramatically from local and private to national budgets. Interest in warnings, flood-proofing, and land use regulations has grown. A study funded by FDAA to develop guidelines for implementation of Section 406 ("Minimum Standards for Public and Private Structures") of the "Disaster Relief Act of 1974" (PL 93-288) is nearing completion. The draft report, Flood Hazard Mitigation Through Safe Land Use and Construction Practices, is a statement concerning what is actually being done, as opposed to what can legally be done. A final report including recommendations will be presented upon conclusion of the field studies.

The Corps of Engineers has long been active in determining the magnitude of the flood hazard and designing control and protection works. It now is giving somewhat more emphasis to nonstructural alternatives. The Department of Housing and Urban Development assists communities in delineating flood boundaries, and calculates rates for the flood insurance program. The U.S. Geological Survey maps flood-prone areas and documents major floods. In the past, the National Weather Service, along with the evaluation and dissemination of warnings, has been involved in compiling flood damages on a national level. The U.S. Department of Agriculture has provided technical aid in rural areas by conducting flood studies and studies of soil processes. Federal funds for research on flood problems have come from the Office of Water Research and Technology. The National Science Foundation has funded studies of the social and economic aspects of flood hazard.

D. Coastal Erosion

Delineation of the Hazard Area

About one quarter of the national shorefront (20,500 miles) is subject to significant coastal erosion (see Figure II-8 and Table II-4). It is a critical problem along 2,700 of those miles. Not all coasts are equally threatened. Social and economic costs of erosion are greatest in the Atlantic and Great Lakes states (Michigan Coastal Zone Laboratory, 1976), whereas the Pacific Northwest, Alaska and Hawaii are least affected.

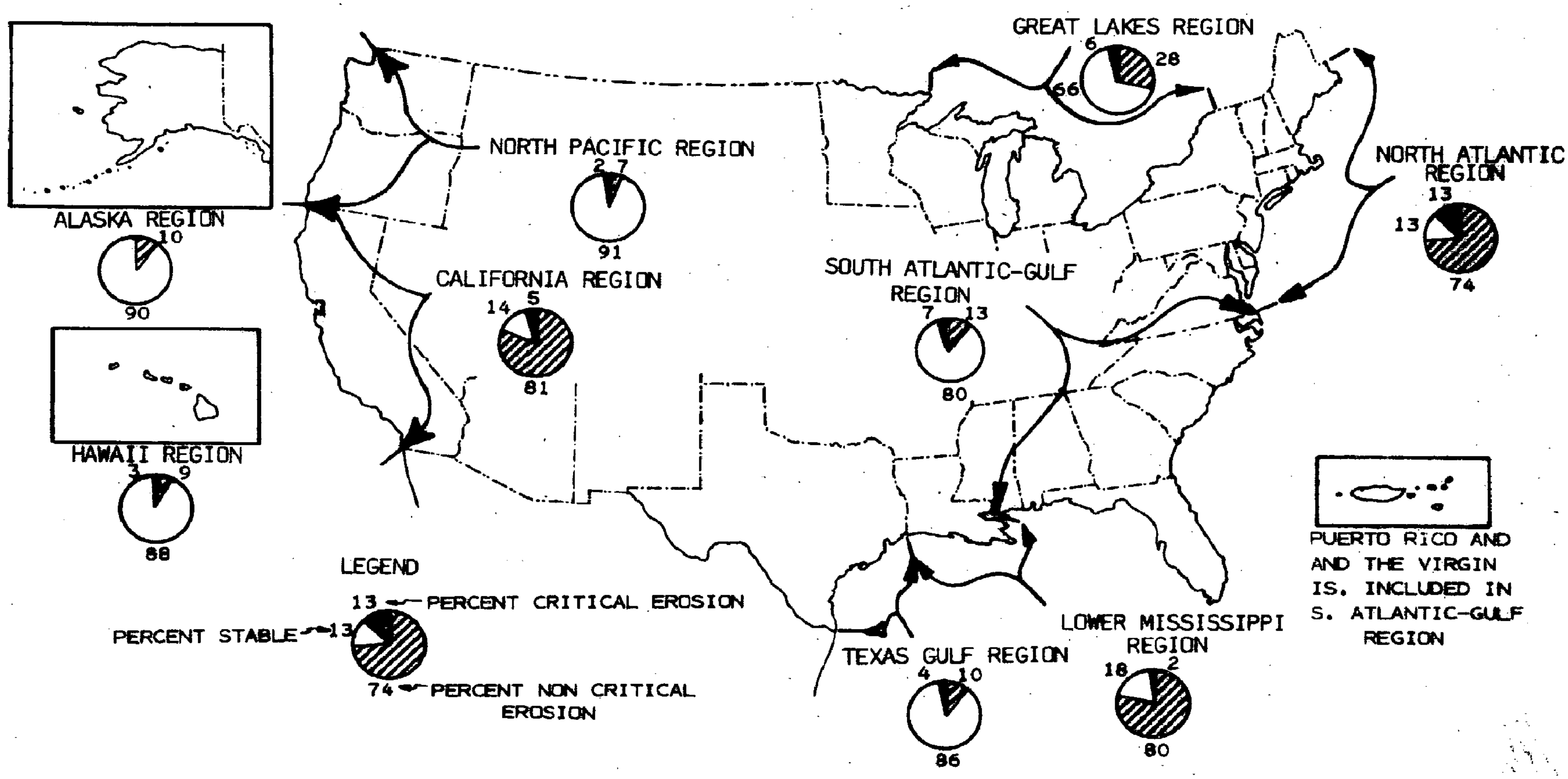
With fifty per cent (50%) of U.S. residents living in coastal counties, population within one mile of the coast growing three to four times faster than the national average, and coastal land commanding premium prices, both the numbers of people and the amount of investment exposed to erosion are steadily increasing (Sorensen & Mitchell, 1975). However, most large cities are located on sheltered sites some distance removed from the open shore. Erosion-prone communities are typically small cities (less than 10,000 population), villages and unincorporated areas dependent upon vacation tourism and recreation income.

Defining the Hazard

Coastal erosion is the set of processes by which more shore zone material (i.e. sand, rock, other sediments) is removed than deposited (Bruun, 1968). This may be accomplished by water, wind, gravity or biological (including human) action. Waves and tides are the most frequent agents of erosion but ice may contribute to structural damages in the Great Lakes, and drought has increased California's erosion losses by reducing the sediment delivery capacity of coastal streams. Overused and poorly vegetated dunes are subject to migration and wind erosion, steep cliffs may collapse after being partially undercut by waves, and many shores protected by limestone or coral reefs suffer slow biological depletion.

In the long run changing sea levels are the ultimate cause of oceanfront erosion (Bruun, 1955; Emery, 1967; Hicks, 1968) but coastal storms coinciding with high tides produce the most immediate and troubling effects (Wood, 1976). On Great Lakes shores spring and fall storms during periods of high water cause the worst problems. In both cases, vulnerable backshore margins, which are not normally exposed to wave action, come under attack.

<u>Characteristics of Eroding Coasts</u> - Natural erosion is most pronounced on exposed coasts composed of unconsolidated materials, with meager sediment supplies, many inlets, deep water close inshore, strong currents, and stormy climates (Inman & Brush, 1973). Human activities exacerbate these problems in a variety of ways. Probably the most important are the development of structures which impede beach sand supplies. These include dams on rivers, shorefront groins and jetties, revetments on headlands which formerly supplied sediment, and occasionally upland soil conservation schemes. Clearance of dune-stabilizing vegetation and truncation of the dunes themselves remove both a source of sediment and a protective barrier against high water and storm waves. Mining of beach sands produces a similar result. Sandy barrier islands may be dessicated by



SEVERITY OF SHORELINE EROSION
(CORPS OF ENGINEERS, 1971)
FIGURE II-8

TABLE II-4

NATIONAL ASSESSMENT OF SHORE EROSION

Region	Total Shoreline (miles)	Critical Erosion (miles)	Non-Critical Erosion (miles)	Non-Eroding (miles)
North Atlantic	8,620	1,090	6,370	1,160
South Atlantic-Gulf	14,620	980	1,840	11,800
Lower Mississippi	1,940	30	1,550	360
Texas Gulf	2,500	100	260	2,140
Great Lakes	3,680	220	1,040	2,420
California	1,810	80	1,470	260
North Pacific	2,840	70	190	2,580
Alaska	47,300	100	5,000	42,200
Hawaii	930	30	80	820
Total For Nation	84,240	2,700	17,800	63,740

(U.S. Army Corps of Engineers, 1971)

lowering water tables due to overpumping wells or diverting domestic waste water and storm runoff into sewer systems rather than septic tanks and dune fields. Elsewhere, land subsidence associated with the depletion of ground water and coastal oil and gas resources may increase wave effectiveness, while channel dredging may undermine adjacent bulkheads and steepen offshore submarine profiles.

Assessment of Losses - Average coastline recession rates of twenty-five feet per year are not uncommon on some barrier islands. Severe storms can remove even wider beaches and twenty foot high dunes in a single night. Such losses are normal aspects of a dynamic natural system. Societal problems arise only when populated areas are affected. On the heavily developed shores in urban areas recessions of one foot per year may be catastrophic.

Average annual losses due to erosion have been conservatively estimated at $300 million (Sorensen & Mitchell, 1975). Most of this stems from damage to private homes, beaches and shore protection structures. Deaths are extremely rare. As coasts continue to attract industries seeking tidewater sites, support facilities for offshore continental shelf (OCS) oil and gas development, nuclear power plants and a stream of second home owners and retirees, the toll of losses is certain to increase.

Adjustments to the Hazard

Most owners of private waterfront land tend to install control and protection devices or to simply bear erosion losses. Privately sponsored protection structures are frequently destroyed or rendered ineffective because of inadequate design and poor construction (U.S. Army Corps of Engineers, 1973). A much wider range of options is utilized by public agencies, although structural protection is also generally preferred. Even the best engineered structures are often subject to heavy damage (see Table II-5). This stems from the difficulty of designing models and protection structures to withstand the extreme physical stresses of marine environments, and also from a lack of coordinated, systematically gathered data on major littoral processes and site conditions.

Control and Protection Works - A majority of erosion control structures are designed either to 1) reduce wave energy (e.g. seawalls, breakwaters, sills composed of sand filled nylon bags), or 2) impede littoral sediment supplies and build up protective beaches (jetties, groins, "sandgrabbers," beach nourishment schemes). Where erosion is caused by starvation in the lee of obstacles to littoral currents, fixed or mobile sand bypassing systems are sometimes established. In 1973, costs of bulkheads, seawalls and other structures were estimated to vary between $25 -300 per linear foot but rising to $5000 per foot for massive bulkheads (U.S. Army Corps of Engineers). Under provisions of the

TABLE II-5

ADJUSTMENTS TO COASTAL EROSION

Adjustments to Loss	Modifications of Loss Potential	Modifications of Erosion Hazard	Adjustments Affecting Hazard Cause
Major	Major	Major	Major
Loss bearing	Coastal zoning	Dune stabilization	Prohibition of beach excavation and harbor dredging
Insurance	Building Codes	Groins	Sand bypassing
Minor	Public purchase of eroding land	Bulkheads, seawalls and revetments	Minor
Emergency public assistance	Land fill	Beach nourishment and "perched" beaches	Removal of river dams
	Minor	Breakwaters	Biological control of marine fauna
	Moving endangered structures	Minor	Reduction in soil conservation activities
	Installing deep pilings	Regulations against destruction of dune vegetation	Storm track modification
	Storm warning and forecasting systems	Phreatophyte removal	
		Artificial seaweed, bubble breakwaters	
		Emergency filling and grading	
		Grading slopes	

(After Mitchell, 1972)

Shoreline Erosion Demonstration Act (1974), Great Lakes and Chesapeake Bay states are experimenting with low-cost protection structures averaging between $50-100 per linear foot (Brater, et al., 1975).

> Beach nourishment is an increasingly preferred adjustment because it involves minimal interference with beach dynamics, can be accomplished with little ecological disruption, and quickly produces a useable recreational and protective beach (U.S. Army Corps of Engineers, 1973a).

The high initial cost ($50-300 per linear foot) and subsequent annual replenishment costs ($5-15 per foot per year) frequently exceed the volume of erosion damages. Some states have empowered localities to establish Beach Protection Districts with taxation powers to fund such long term maintenance programs (e.g. Virginia Beach's "sand tax"). Inventories of submarine sand supplies and improvements in dredging technology have increased the prospect of continuous beach nourishment from offshore sources. For example, Hawaii's Submarine Sand Recovery System (SSRS) with costs of $3.01-$5.49 per cubic yard compare favorably with $15 and up for delivery from inland sources (Moberly, et al., 1975).

Beachfront homes are often placed on tall wood or steel pilings for protection against both flooding and erosion. Elevation above one per cent (1%) probability flood levels is now a general land use requirement in communities seeking to avail themselves of Federal flood insurance. Pilings may preserve exposed buildings from destruction while surrounding beaches, dunes, roads, utility lines and other infrastructure are heavily damaged.

> Thus piling can indirectly encourage continued post-disaster redevelopment of erosion hazard areas. However, under the National Flood Insurance Program, the elevation requirement for structures in areas subject to wave wash states that the pilings be driven below the erodable sand.

Dune stabilization - by means of vegetative plantings and sand fences is often practiced by individuals, municipalities and public agencies, in conjunction with other adjustments (U.S. Army Corps of Engineers, 1957; 1969; 1970; Dolan, et al., 1973).

> To achieve success, this strategy requires strict land use control to minimize occupance of, or passage through, the vulnerable outer dune lines.

Other structural adjustments to coastal erosion such as weather modification to reduce storms, self-dredging harbors, floating breakwaters, and artificial seaweed, are either at experimental stages or have limited utility.

Most coasts which have received structural protection against erosion are already heavily developed or held as public open spaces.

There is little evidence that such works encourage further invasion of hazard prone areas except where they are part of cooperative erosion control and hurricane protection schemes.

Under existing law, Federal shore protection funds cannot be used to protect private land unless there is a significant public benefit. Except in Connecticut and Maryland, where state assistance is available to private landowners, major public assistance is denied to the privately owned 2/3 (67.67%) of America's critically eroding coasts (Coastal Zone Research Corporation, 1975).

Land Use Management - The widespread enactment of land use controls to mitigate erosion hazards is a post World War II phenomenon stemming from disenchantment with traditional structural protection practices and also from a growing need to resolve intense commercial, industrial, residential and recreational conflicts for coastal locations. Further, about thirty per cent (30%) of critically eroding shores are publicly owned (parks, nature reserves, recreation areas, historic sites). They have been subject to use regulations such as restrictions on access or permitted activities (U.S. Department of the Interior, 1976).

> Erosion risk maps are a prerequisite for effective land use controls.

These generally depict average rates of historical shoreline change as determined from maps, charts, surveys, aerial photographs and similar sources. Such maps have been, or are being, prepared for the Great Lakes and Chesapeake Bay shorelines which suffer from severe coastal bluff recessions (Joint Federal Regional Council, 1974). The Federal Insurance Administration is currently working with the Great Lakes Basin Commission to study the erosion hazard, and will soon be mapping the hazard areas and developing specific regulatory requirements for these areas. Exposed oceanic shores are subject to great variations in erosion rates and there risk mapping is a more complex task. Nevertheless, Virginia's Shoreline Situation Reports and Maryland's Shore Erosion Mapping program are prototypes which may be useful elsewhere.

> Public dissemination of information about erosion hazard is a necessary corollary to risk mapping.

This need is partly met in specific locations by Corps of Engineers Coastal Flood Plain Information reports. In some states, erosion hazard data is incorporated into handbooks for coastal developers and property owners (Carroll, 1975; Bird, 1975). Elsewhere it is written into plat books and mortgage agreements.

In addition to public acquisition, land use controls may involve clearance or relocation of structures ($5000-7000 to move a threatened house is typical). In many places, either strategy (i.e. acquisition or relocation), can be a preferred alternative to structural protection

(Great Lakes Basin Commission, 1976). The high cost of shorefront property and its substantial income producing potential frequently deter public acquisition, although methods such as purchase of development rights or easements, purchase-leaseback agreements, and delayed payment schedules, can ease the problem. Major legal complexities also hinder public land acquisition. Along heavily developed shorefronts, many different interest groups, municipal government agencies and various citizen groups, may be opposed. Public ownership is often vigorously resisted because it raises the possibility of open and unrestricted use of beaches by non-residents.

A wide range of other land use controls also exists. These include moratoria on building construction, zoning, building codes, setback lines, subdivision regulations, dune conservation and sand removal ordinances, special tax districts, transfer of development rights, Planned Unit Development regulations, drainage and sanitary codes, seawall standards, scenic easements and permits for special uses.

All coastal states possess some regulations designed to reduce vulnerability to coastal erosion. Most northeastern states now have a comprehensive range of statutes pertaining to: construction of shore protection works, issuance of permits for structures in coastal waters, removal of sand and gravel from beaches, alteration of dunes, preservation of wetlands, and regulation of subdivisions in coastal hazard zones. Many Great Lakes states have also adopted, or are in the process of adopting, statewide subdivision controls, erosion risk zones or setback ordinances. A 1972 survey showed that no more than eleven per cent (11%) of shorefront communities had adopted any one of the three most popular land management tools to control erosion (i.e. setback lines, controls on structures, dune conservation statutes) (U.S. Water Resources Council, 1972). Passage of the Flood Disaster Protection Act of 1973 (P.L. 93-234) significantly increased this number.

Relief and Rehabilitation - Erosion losses generally are borne by affected individuals and groups. Voluntary assistance from the Red Cross or the Salvation Army is generally not available because most coastal property is used for recreation rather than permanent residence. Nor can erosion losses be deducted as a business expense from income tax returns (American Shore and Beach Preservation Association, 1970).

> Presidential declarations can make disaster aid available to erosion victims and Public Law 93-288 also provides emergency aid if erosion is associated with storms (avulsion).

Public Policy

Trends in Adjustment - In the nineteenth century coastal protection was largely the responsibility of shorefront property owners and municipalities. Subsequently, states established agencies to oversee erosion control (New Jersey Board of Commerce and Navigation, 1922). The U.S. government has been active in this field since 1930. Protective works such as seawalls and bulkheads were favored during the 1930's and 40's. Beach nourishment and dune stabilization were added during the 1950's, and sand bypassing systems for inlets were adopted during the 1960's. Since that time there has been a shift towards 1) land use management as a promising alternative strategy (U.S. Army Corps of Engineers, 1971); and 2) the design of moderate cost engineering devices suitable for small scale structural protection - especially in sheltered waters. These objectives reflect both the findings of the National Shoreline Study (1971) (U.S. Army Corps of Engineers, 1971a), and new Federal legislation.

The Coastal Zone Management Act may help to integrate structural protection works within a larger management framework. Identification of erosion risk zones, designation and regulation of hazard-related Geographic Areas of Particular Concern, or adoption of similar management statutes, are widespread features of evolving plans in affected areas.

In 1974 Congress appropriated $8 million for the Shoreline Erosion Demonstration Act and established a five-year program of low cost projects on sheltered waters to demonstrate engineering and vegetation adjustments.

Federal Protection Programs - The Corps of Engineers carries out most Federal coastal protection work. Up to seventy per cent (70%) of the costs of structures, beach nourishment schemes, dune stabilization and other works on non-federal public land are paid for by the Federal government. Such money is periodically appropriated by Congress in omnibus Civil Works acts. Where protection of private land results in substantial public benefit, local and state governments usually contribute at least fifty per cent (50%) of the total costs and the Federal government provides the balance. If no public benefits are foreseen, the Corps of Engineers can only offer advice on appropriate technology and related subjects (U.S. Army Corps of Engineers, 1973). The sole exception is for emergency projects costing less than $1 million, and these may be undertaken without Congressional approval. Some states also provide public assistance to private landowners and many more have state-funded protection programs for public shores.

Insurance - Since the 1973 expansion of the National Flood Insurance Act of 1968, adoption of insurance against erosion has experienced a dramatic increase. Previous attempts to market erosion insurance failed to attract sufficient subscribers, but extension of the federally subsidized flood insurance program to encompass storm-caused erosion losses has proved attractive to property owners. Single family residences can now be insured up to $70,000 and multi-family homes for up to $200,000 at low premium rates.

There are no clear guidelines by the Federal Insurance Administration to determine whether erosion losses are caused by storms (avulsion) or by long term processes (erosion). Only the former qualifies for reimbursement. Considerable delays occur between a community's acceptance into the "emergency" phase of the program (minimum land use regulations required), and its passage to the "regular" phase (strong land use controls required).

Interaction of Adjustments - Adoption of a specific response to erosion can: increase, decrease, or have no effect on the likelihood of other adjustments being adopted. For example, if erosion control and protection structures are adopted it is likely that they will be complemented by warning systems and relief and rehabilitation programs, whereas it is less likely that non-structural controls and land use management tools will be employed.

In most communities a mixed set of adjustments is preferred to single component programs. The Federal flood insurance and land use zoning package is one such widely adopted scheme. Other sets include: 1) structural protection, warning and relief programs; 2) beach nourishment, dune stabilization and piling schemes; and 3) long range forecasting and permanent evacuation of high risk areas. Although potentially of equal effectiveness, each set of responses employs different means to reduce damages, produces different costs and will have different effects. The most advantageous combination of adjustments will vary in response to local conditions.

Erosion adjustments may also mitigate other hazards, and land use controls usually serve multiple purposes often unrelated to hazard mitigation.

Costs - To the cost of capital construction and annual beach nourishment must be added considerably greater indirect and intangible costs of social, environmental and aesthetic disruption which accompany such schemes. Some observers suggest that present programs cost more than the land is worth, but sensitive benefit-cost analyses are presently lacking. It does appear, however, that erosion damages are increasing steadily and that protection strategies which depend solely on structural devices have had limited success in curbing erosion losses.

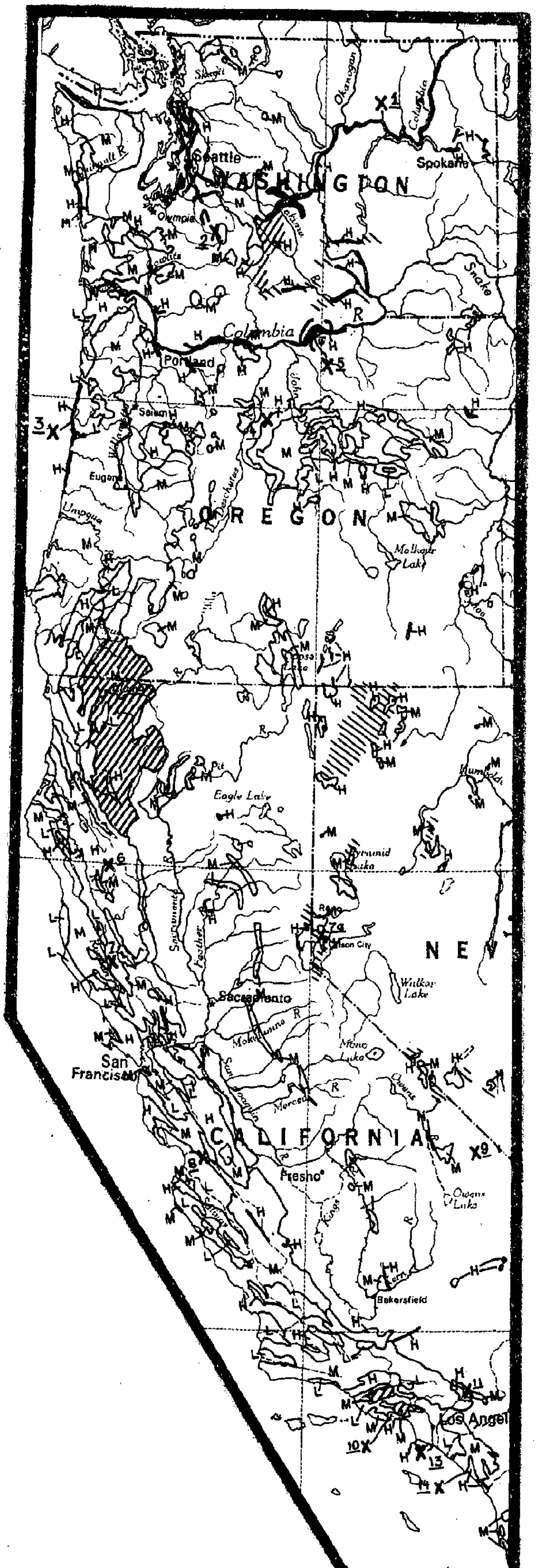
E. Landslide

Most coastal landslide activity is found along the Pacific, including the states of California, Oregon, Washington, Alaska and Hawaii. Although landslides occur in other coastal states, they do not generally occur in their coastal zones (see figures II-9 & 10).

Landslide is a highly localized hazard. While much of the Pacific coast is affected by landslides, the hazard is limited in its extent to

FIGURE II-9

PRELIMINARY LANDSLIDE OVERVIEW MAP OF THE WASHINGTON-OREGON-CALIFORNIA COAST REGION



(RADBRUCH-HALL AND OTHERS, 1976)

AREA OF HIGH LANDSLIDE INCIDENCE (MORE THAN 15 PERCENT OF AREA UNDERLYING ROCK OR EARTH MATERIAL ESTIMATED TO BE INVOLVED IN LANDSLIDING)

AREA OF MODERATE LANDSLIDE INCIDENCE (LESS THAN 15 PERCENT BUT MORE THAN 1.5 PERCENT OF AREA OF UNDERLYING ROCK OR EARTH MATERIAL ESTIMATED TO BE INVOLVED IN LANDSLIDING)

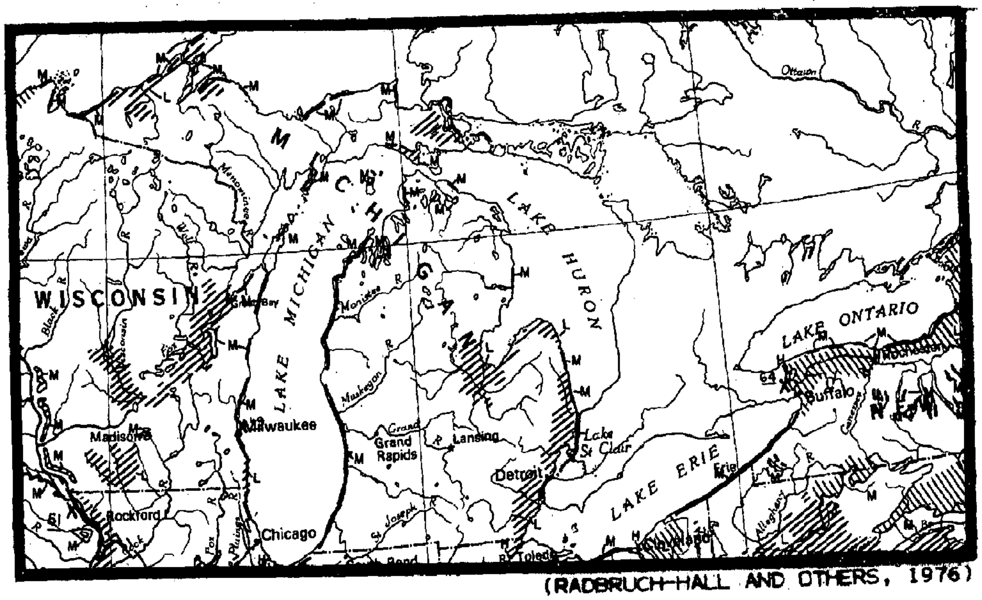
AREA OF LOW LANDSLIDE INCIDENCE (LESS THAN 1.5 PERCENT OF AREA OF UNDERLYING ROCK OR EARTH MATERIAL ESTIMATED TO BE INVOLVED IN LANDSLIDING)

AREA OF HIGH LANDSLIDE SUSCEPTIBILITY (LANDSLIDE SUSCEPTIBILITY OF UNDERLYING ROCK OR EARTH MATERIAL ESTIMATED TO BE HIGH; NATURAL OR ARTIFICIAL CUTTING OR LOADING OF SLOPES OR ANOMALOUSLY HIGH PRECIPITATION MAY CAUSE LANDSLIDING INVOLVING MORE THAN 15 PERCENT OF THE ROCK OR SOIL)

AREA OF MODERATE LANDSLIDE SUSCEPTIBILITY (LANDSLIDE SUSCEPTIBILITY OF UNDERLYING ROCK OR EARTH MATERIAL ESTIMATED TO BE MODERATE; NATURAL OR ARTIFICIAL CUTTING OR LOADING OF SLOPES OR ANOMALOUSLY HIGH PRECIPITATION MAY CAUSE LANDSLIDING OF BETWEEN 15 AND 1.5 PERCENT OF THE UNDERLYING ROCK OR SOIL)

100 0 100 200 MILES

NOTE: THIS SCALE SHOULD ALSO BE USED FOR FIGURE II-10



(RADBRUCH-HALL AND OTHERS, 1976)

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AREA OF MODERATE LANDSLIDE SUSCEPTIBILITY (LANDSLIDE SUSCEPTIBILITY OF UNDERLYING ROCK OR EARTH MATERIAL ESTIMATED TO BE MODERATE; NATURAL OR ARTIFICIAL CUTTING OR LOADING OF SLOPES OR ANOMALOUSLY HIGH PRECIPITATION MAY CAUSE LANDSLIDING OF BETWEEN 15 AND 1.5 PERCENT OF THE UNDERLYING ROCK OR SOIL)

PRELIMINARY LANDSLIDE OVERVIEW MAP
OF THE GREAT LAKES REGION

FIGURE II-10

small well-defined, although not always identifiable, locations. What may be a problem for one person, may not be so for his neighbor.

Landslides become hazardous when they coincide with the activities of man. In coastal environments some of the areas most aesthetically desirable are also areas of high landslide activity. In fact, landsliding is one of the processes which creates visually pleasing coasts. When people occupy such areas, they are exposed to risks of landslide damages. As recent years have witnessed a rapid population growth in the coastal environment, the problem has become more severe. Losses from landslides will continue to increase with the growth of population unless specific measures are taken to reduce loss.

Defining the Hazard

A landslide is the perceptible downslope movement of rock, debris, soil, or some combination of these materials. This excludes from consideration very slow types of erosion and soil movements which are found in coastal environments. Regional perceptions of landslides differ; what is called a landslide in California may be considered erosion along the Great Lakes.

In general, landslides are classified into three types of movement - falls, slides, and flows (see figure II-11). Also important in describing landslides is the nature of the material in motion which varies in particle size from large rocks to very fine soils. Falls are simply the free falling of any size material. There are two types of slides: planar slides refers to the non-rotational or straight movement of a large block (or blocks) of materials, and slumps are rotational movements of a single or multiple slide mass. Flows are characterized by the fluid-like movement of slide material.

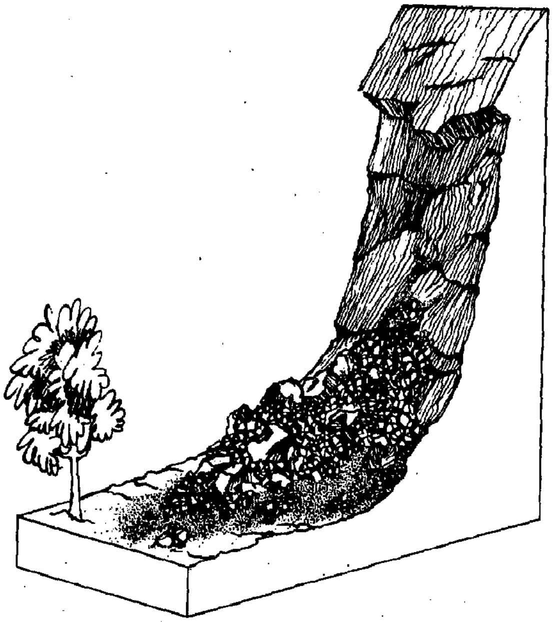
Falls of all size material, slumps of rock and smaller debris, and flows of soil (mudflows) are all common to the coastal zone.

Delineating the Hazard

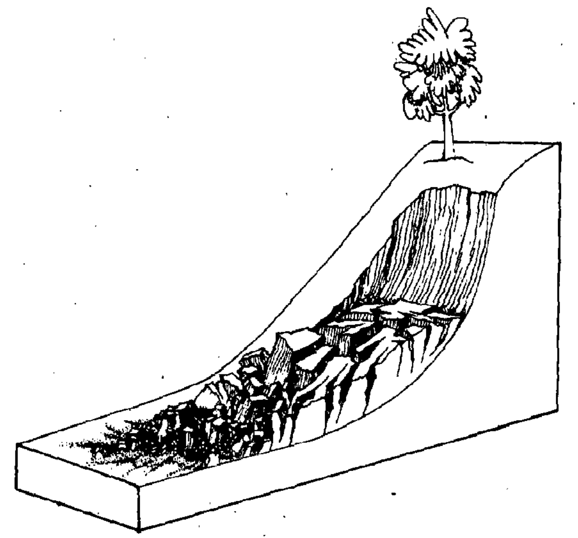
Many areas of landslide activity are easily seen in the light of historical evidence. Other potential hazard zones are difficult to recognize, even to the expert eye. Currently a wide variety of methods exist for identifying landslides. Such methods involve the use of both historical evidence of landsliding and a variety of other types of geological data related to this hazard. The final product of the identification process is most typically in map form. However, not all maps have the same meaning. They vary in their scale, content, and means of preparation.

The scale of a landslide identification map may determine its use (see Figure II-12). Small scale maps are, in general, of limited use for planning. While they provide a picture of the extent of the hazard, specific decisions cannot be made from the broad information they contain. Large scale maps at scales from 1" = 2,000' up to 1" = 500' are of greater use in formulating methods to reduce losses from landslides. As would be expected, the larger the map scale, the more expensive it is to prepare.

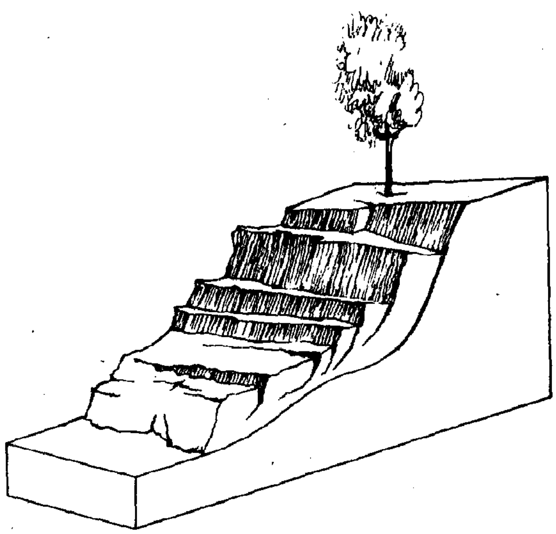
There are a wide variety of landslide maps. They differ in scale, information presented, and intended use. For example, a simple type of landslide map shows the location and areal extent of landslide deposits. Maps of this type are commonly prepared from interpretation of aerial photographs with little or no field checking for accuracy. Where these maps have been field checked, however, they were determined to be reliable indicators of the locations of past landslide activity. A more refined map might make use of information on the kinds of geological materials present, correlate these with existing landslide deposit maps and generate maps of the distribution of landslide susceptible materials. These maps



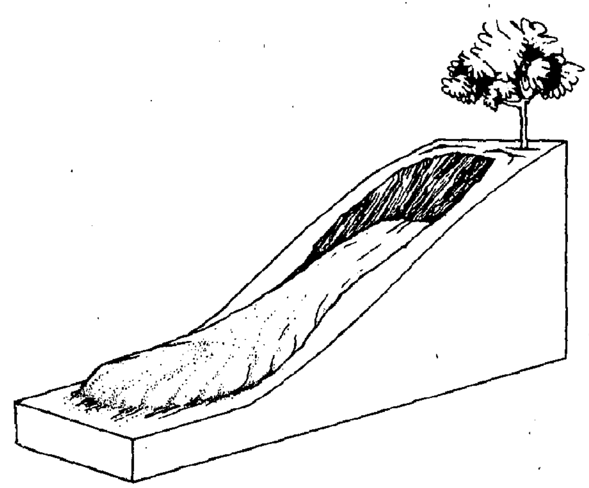
A Rockfall: rock masses that move primarily by falling through the air.



B Debris slide: incoherent or broken masses of rock and other debris that move downslope by sliding on a surface that underlies the deposit.



C Slump: coherent or intact masses that move downslope by rotational slip on surfaces that underlie as well as penetrate the landslide deposit.



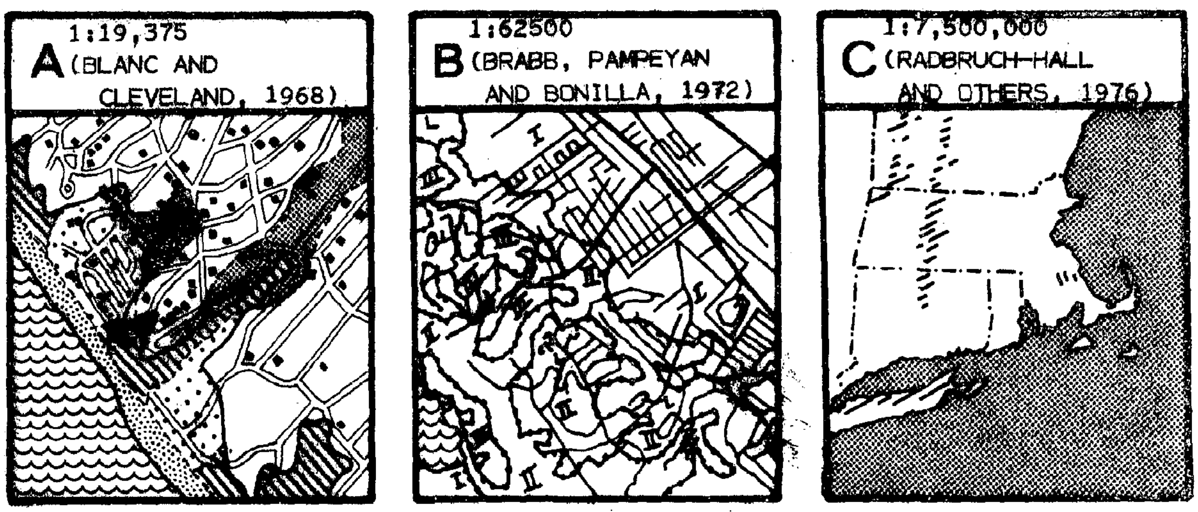
D Earthflow: soil and other colluvial materials that move downslope in a manner similar to a viscous fluid.

FOUR COMMON TYPES OF LANDSLIDE (NILSEN AND BRABB, 1972)

FIGURE II-11

MAP SCALE		MAP USES
C	SMALL	
1:5,000,000		DELINEATING GEOGRAPHICAL EXTENT OF LANDSLIDES
1:500,000		DRAWING ATTENTION TO HAZARD POTENTIAL
		REGIONAL PLANNING
B		SUBDIVISION PLANNING AND LOCATION
1:50,000		PRELIMINARY SITING OF PUBLIC FACILITIES
A		GENERAL ZONING
1:5,000		DETERMINATION OF ACTURIAL RATES
		MICRO ZONING
1:500		DESIGNING CONTROL/PROTECTION WORKS
	LARGE	

SELECTED MAP SCALES



RELATION OF LANDSLIDE MAP SCALES
AND POTENTIAL USES
FIGURE II-12

obviously require substantial fieldwork. The maps can be further refined by combining information on landslide deposits and geological materials with other parameters such as steepness of slope, slope aspect, vegetation or unfavorable dip of underlying strata. Other maps (see for example Nolan and others, 1976) provide information on the current rates of intensity of landslide processes by mapping deposits on aerial photographs of the same area taken at different times. Users of landslide maps should be familiar with the methods of preparation, intended use, and limitations. Among the wide variety of maps the greatest distinction is between those which show the potential for future landsliding (susceptibility) and those which depict historical incidence.

Adjustments to the Hazard

Traditionally, the chief means of preventing damages from landslides involved the application of engineering technology to stop the slide from moving or to stop it after it had been released. Often, such efforts were not effective, and could be done only at high cost (Sorensen, et al., 1975). Currently a much broader range of alternative adjustments is available. The major types of adjustments include:

1. Prediction
2. Protection
3. Land Use Management
4. Disaster Preparedness
5. Relief and Rehabilitation
6. Insurance

Because of the variable nature of the hazard, no single pattern of adjustments is universally effective or unique to the coastal zone.

Prediction - is the process of identifying the location, time, and magnitude of landslide activity. At present, techniques exist which can reliably define where landslides occur.

> As of yet, however, it is impossible to determine precisely the magnitude of the landslide as measured by the volume of material that moves. Thus, the data on which to make a prediction in probabilistic terms is lacking. What we can predict are locations susceptible to landsliding. This is an important prerequisite to using some of the other adjustments that will be described.

Protection - is the application of geological engineering knowledge and practice to prevent or correct landsliding. Two approaches are used: improve the stability of a slope, or control the impact of the slide. Stability can be improved by increasing the resistance to activation. Some techniques include building restraining structures, smoothing surfaces or installing subdrainage systems. Improved stability can also be achieved by removing the forces which cause activation. This is accomplished by excavation of earth materials or drainage. The chief means of controlling impact focuses on the use of engineering works to alter the landslide after it is released by diverting or stopping the flow of materials.

The effectiveness of protective methods varies according to the type of landslides, causal factors, maintenance of the structures, the geology of the slide area, and changes in the land use in the protected area. The considerable economic costs of protective measures are also open to question. Many control structures are aesthetically undesirable. Finally, it should be noted that any use of protective measures is based on an adequate identification of the landslide hazard.

As with protection, land use management, at both long-range regional and immediate detailed levels, is closely allied with, and usually dependent on hazard mapping. As an adjustment to landslides, land use management guides the types and amount of building and other development in hazardous areas in a manner which minimizes damage potential. Specific measures include:

1) the regulation of development through zoning, setback, subdivision and grading regulations, and building, sanitary and well codes; and

2) development policies as reflected in land acquisition, urban renewal, relocation and location of public service buildings and other structures, such as roads, sewers and pipelines.

If costs from landsliding are increasing due to human encroachment of hazardous locations, and it is possible to identify locations of potential damage, losses can be reduced by planning for land use that is compatible with the landslide hazard.

Disaster Preparedness - involves developing the ability to respond to the needs of a community in a smooth or stable manner once it is known a hazard event is imminent or has occurred. Since most landslides are small individual events, the existing emergency functions are generally capable of responding to the situation.

Disaster preparedness is particularly important when large scale landsliding occurs. Often in these situations the landslide has been caused by another hazard - intensive rainfall or earthquakes, and disaster preparedness responses to the causal hazard can be applied to the landslide problem.

Relief and Rehabilitation - provides aid to victims of a landslide disaster. Currently Federal Disaster Relief Assistance is available under Public Law 93-288 to victims of major "landslides" and "mudflows". However, under this law Federal aid is not available to the victims of the more frequent small, individual landslide events.

Currently insurance to cover the vast majority of landslide losses is not available. The National Flood Insurance Program (Public Law 90-448) offers coverage for mudslides triggered by flooding. To date, no landslide losses have been covered by the NFIP. In the future, a separate Federal insurance program covering a range of landslide types may be developed.

> The link between hazard identification and loss reduction is crucial. Landslide mapping is required before protection, land use planning, preparedness planning or insurance can be employed to effectively reduce loss. Once the landslide area has been delineated, the planner has a variety of tools at his disposal to reduce future losses in accord with local situations.

Federal Policy and Programs

Due to the localized nature of the hazard, no explicit national policy exists for landslides. Most Federal policy concerning landslide originates from policy dealing with other natural hazards. The United States Geological Survey has the greatest Federal involvement with landslides, but this involvement rarely extends to policy issues.

The following Federal agencies deal with the landslide hazard in some manner.

United States Geological Survey - Department of the Interior.

The USGS established a National Landslide Hazard Reduction Program in the Denver, Colorado Federal Center in the Fall of 1976. The bulk of this program is devoted to physical research, and is applicable or devoted to delimitation of landslide risk. Much of this work has been in mapping landslides and potential landslides in the San Francisco Bay Region, although efforts are being expanded in many other parts of the country. Considerable information on landslides, particularly on the physical dimension of the hazard, can be obtained from the Landslide Information Center located in the Engineering Geology Branch of the USGS in Denver.

Soil Conservation Services - U.S. Dept. of Agriculture

The National Cooperative Soil Survey program includes in their published survey the names and locations and past evidence of soils susceptible to landslides. Technical assistance is also available from the USDA Soils Conservation Service to individuals and government agencies concerning development of sites where susceptibility to the hazard may exist.

Federal Insurance Administration - Housing & Urban Development (HUD)

Currently the FIA is investigating the possibilities for a federally subsidized landslide insurance program.

Federal Highway Administration - Department of Transportation.

The FHA applies engineering technology to prevent damages and maintain safety on Federal highways.

Current Federal involvement is slight, and nothing resembling a national policy, is identifiable. Most landslide policy is formulated on a local basis with respect to individual problems and results in piecemeal strategies.

Experiences

Two experiences with landslide adjustments illustrate some of the benefits and disadvantages in changing local policies.

It has been asserted that land use management has great potential for reducing landslide losses. This is demonstrated by the Los Angeles history of adopting regulations to deal with landslides over the period of 1952 to 1969. Slosson (1969) sought to determine if practical and efficient use of engineering geology and control procedures via codes and supervisions could produce safe and economical property developments. His findings indicated that land use management techniques could drastically reduce losses. Before 1952, when Los Angeles had no codes or regulations, 10.4% of the approximately 10,000 sites constructed were damaged by landslides. Of the 27,000 sites constructed in 1952-62, when lenient codes were in effect, 1.3% were subject to damages. Finally, between 1963 and 1969, of the 11,000 sites developed only .15% were affected by landslides. This reduction in loss is mainly attributed to modern grading codes and soil and geological engineering practices required during design and construction of buildings. To date, there are no state or Federal guidelines for developing local programs as there are for flood hazard.

This problem is illustrated by the Portola Valley, a small, affluent community near San Francisco (Mader & Crowder, 1969). Approximately sixty per cent (60%) of Portola Valley has precipitous slopes subject to sliding. While the problem was recognized soon after the town was incorporated in 1964, it took two dramatic landslides to evoke any town action. This example reflects a lack of perception of risk by the lay users, as well as influence exerted on management due to vested interests of many, including homeowners, land developers, realtors, and financial institutions. Moreover, a depleted tax base is the concern of community politicians. Consequently, when land use management is attempted, political pressures are exerted to gain exemptions, resulting in increased loss potentials. In addition, there is commonly a lack of coordination between the various regulating elements that are basic to a successful land use management program.

F. Earthquake

While no single region of the United States is completely safe from an earthquake, a significantly large part of the coastal zone is in relatively high risk (see figure II-13). The majority of seismic activity takes place where massive plates of the earth's crust are slowly moving in opposition. Pressure which builds along the boundaries or plates is partially released by earthquakes. One of these boundaries extends along the Pacific coast from Alaska on through southern California. Stretches of the coast are subject to considerable seismic activity, although damaging events occur infrequently.

The second region of major risks lies along the eastern seaboard, although the geologic explanation for this is not clear. The nature of the risk here is quite different. Major earthquakes can occur in locations where evidence of seismic activity predates recorded history. While the Pacific Coast experiences many earthquakes, the eastern U.S. experiences few. Evidence suggests, however, that in certain areas of New England, New York and the Carolinas the possibility of large and potentially damaging earthquakes exists. The nation's experience in the past 100 years would suggest California and Alaska have the highest frequencies of serious earthquakes. In the short run the damages may prove less crippling in California and Alaska than in some other areas because these states are better prepared to deal with the hazard.

The national record of earthquake loss is one of good fortune when viewed in the context of potential losses. No genuinely catastrophic event has occurred since the Alaska quake of 1964. A major earthquake could easily strike in a coastal area within the next three decades. Potential losses range to billions in damage and tens of thousands of fatalities. Such damage potentials can be reduced with a comprehensive earthquake hazard reduction program.

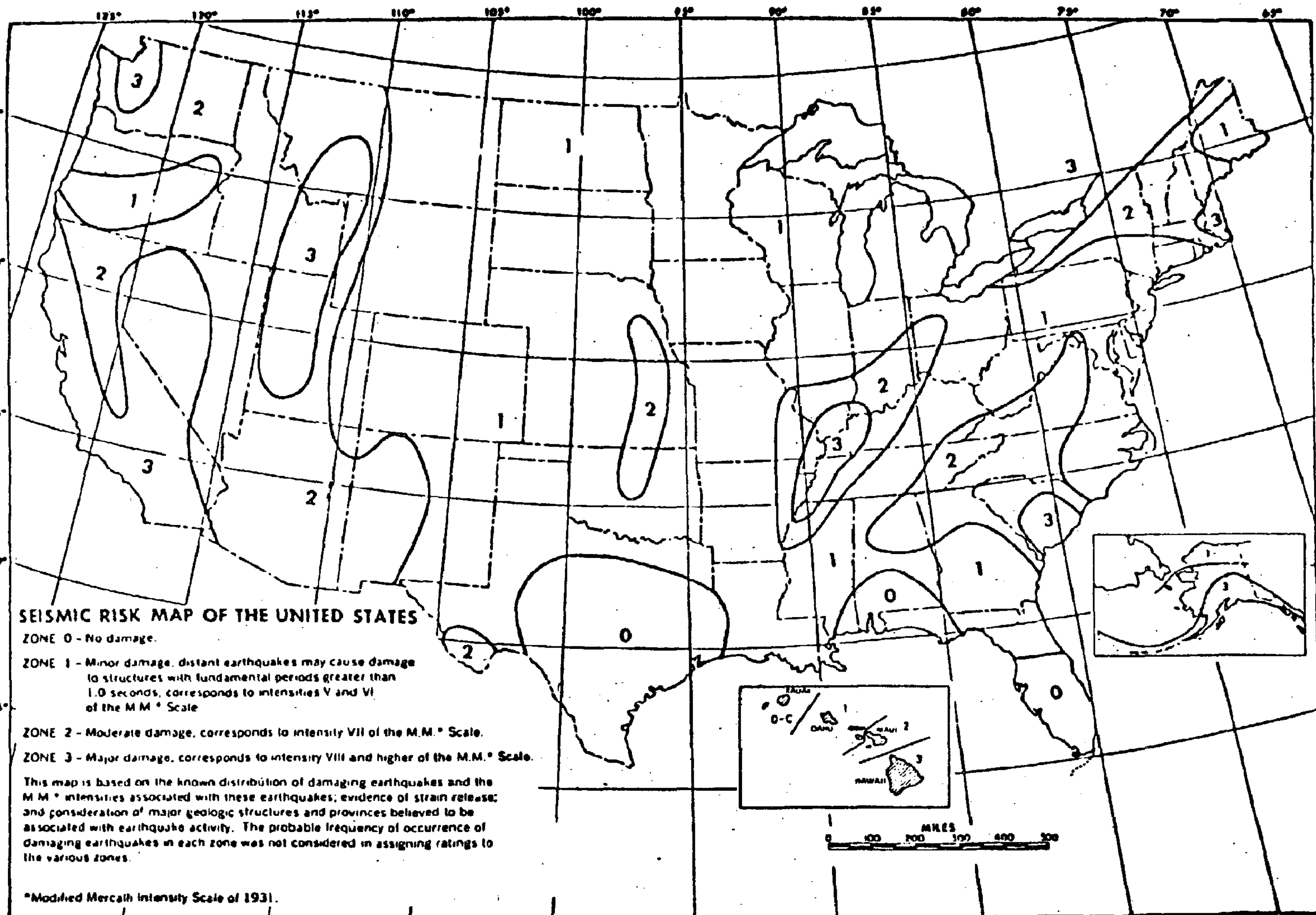
Delineating the Hazard

How does the planner delimit the risk of earthquake damages? At present four means of delineating the earthquake hazard exist, and none is ideal from a planning viewpoint.

One method makes use of generalized risk maps, which show potential for damages based on the frequency of recorded seismic events. These are prepared at small scale, which limits their use. Generalized risk maps <u>do not</u> provide any measure of the probability of future earthquakes. These maps sensitize people to the existence of problems in a non-technical manner.

FIGURE II-13

SEISMIC RISK MAP OF THE CONTERMINOUS UNITED STATES



(Office of Emergency Preparedness, 1972, Volume 1)

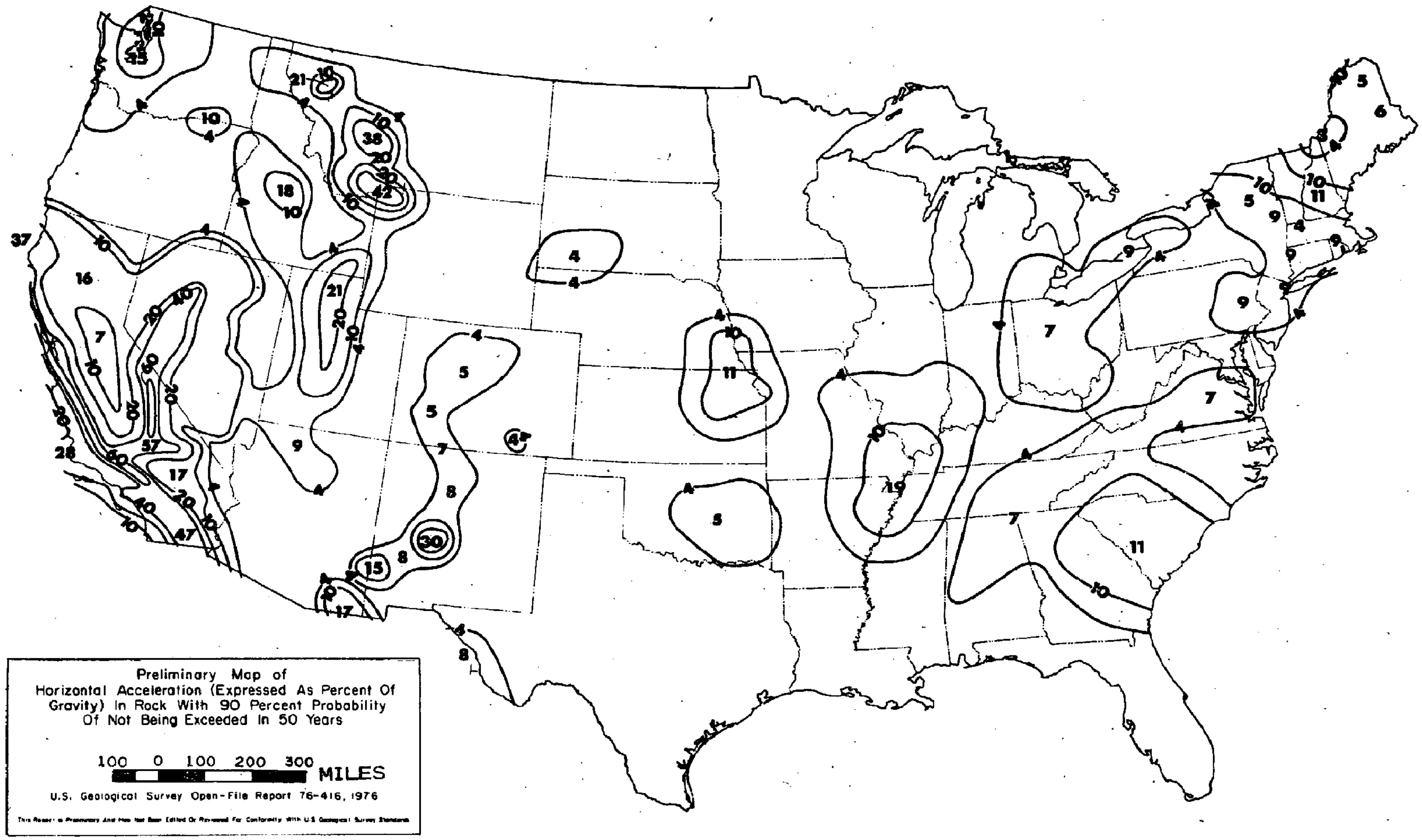
A second means is to predict the distribution of strong ground motion (shaking) during an earthquake. This can be estimated in probabilistic terms by analysis of current seismicity for an area and the way seismic waves travel through the ground. Ideally this type of map can be used with other information, in the estimating of damage probabilities because it measures the probability of factors causing earthquake damage. Figure II-14 provides an example of this type of map (Algermissen and Perkins, 1976). This has limited applicability. The technique is new, and its proper use often requires professional assistance. As they become available at large scale and are better understood, such maps will be useful in technical land use planning.

A third means uses surface faulting as an indicator of earthquake risk. First, while most earthquakes occur on active faults, the presence of faults does not mean an earthquake will occur, or is even likely. Second, while damages do occur directly over a fault when the fault moves, they are not necessarily limited to the immediate fault vicinity. Fault maps have limited utility in planning adjustment to earthquake hazard.

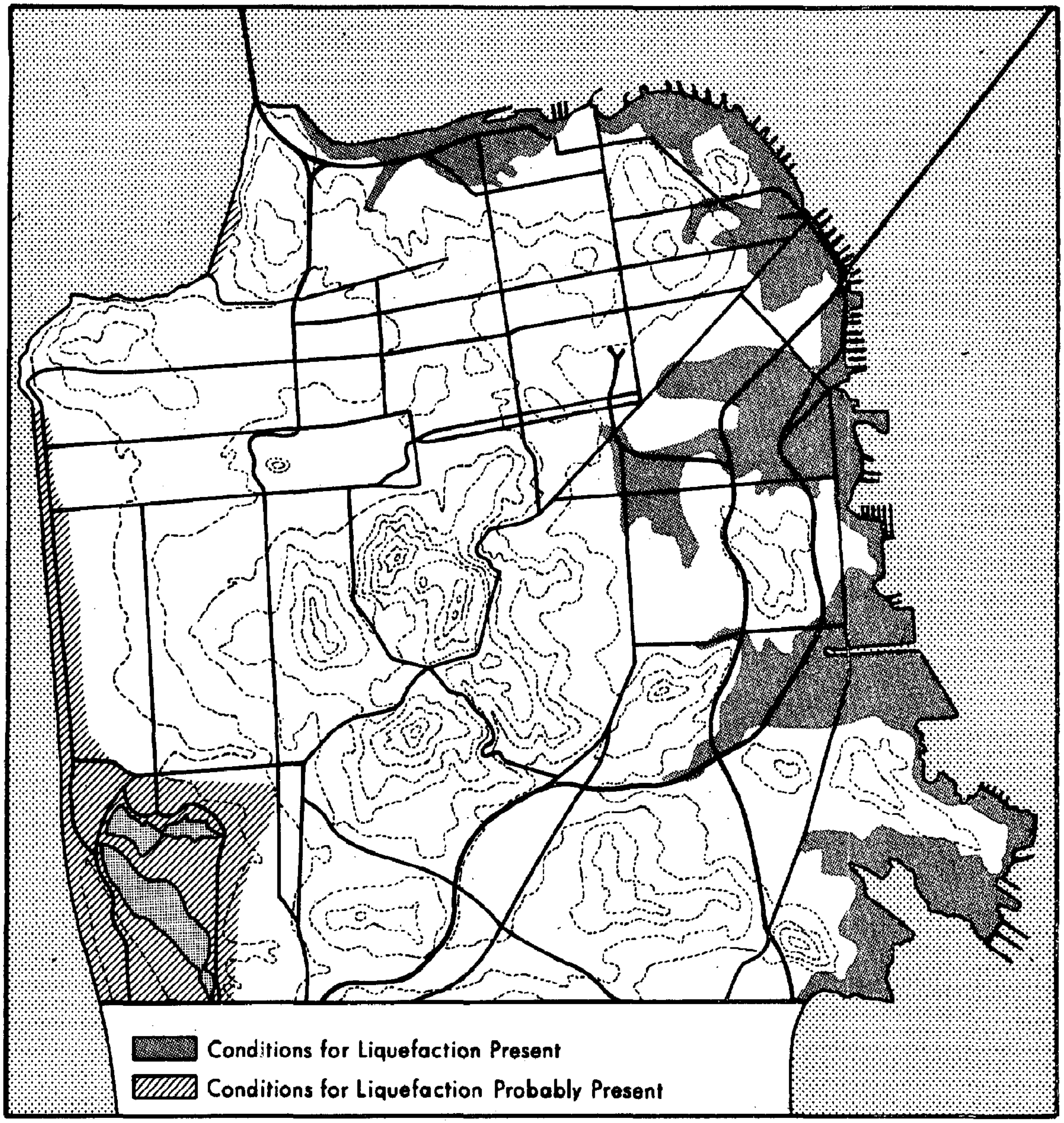
The fourth method of delineating the hazard is by identifying ground conditions which lead to damages when shaking takes place. This involves identifying unstable slopes that are susceptible to landsliding (see section on landslide hazard) and soils subject to liquefaction (see figure II-15). The identification of these associative hazards triggered by earthquakes may be the most useable information the coastal planner has on areas of potential earthquake damages. They form the basis for most current land use planning with respect to earthquake hazard, are especially useful when the suitability of a proposed investment such as a power plant or a bulk loading facility is under review, and will continue to be valuable for this purpose.

Besides the spatial identification, it is important to estimate the size of earthquake events. The size is measured by both magnitude and intensity, and often the two are confused. Magnitude scales, the most common being the Richter scale, measure the energy released by an earthquake. The Richter scale is logarithmic, that is, a magnitude of 5.0 means 10 times the amplitude of ground shaking and 31.6 times the release of a magnitude 4.0, 100 times in amplitude and 1000 times in energy more than a magnitude 3.0, and so forth. In general, the greater the magnitude the more severe the damages, although many factors interact to determine damage severity.

Intensity scales are specifically designed to measure the effect of an earthquake on people, structures, and the earth's surface. The most common scale, the modified Mercalli, is calibrated to twelve degrees of severity. Roman numeral I denotes effects which are barely perceptible, while at the other end XII signifies total destruction. Each discrete seismic event has one magnitude related to the energy released. That same event will have different intensities at different



PRELIMINARY MAP OF HORIZONTAL ACCELERATION
FIGURE II-14



POTENTIAL FOR LIQUEFACTION IN SAN FRANCISCO

(San Francisco Department of City Planning, 1974)

FIGURE II-15

locations. Intensity usually decreases with distance from the epicenter. The maximum intensity, usually near the earthquake source, is often used to characterize the size of the shock. (See Appendix C).

It is practicable to simulate the damages from a quake of assumed magnitude, taking into account differences in ground conditions, land use and buildings (see figure II-16, Friedman, 1976). In addition, these types of damage assessments are being integrated into models that evaluate the total economic impact of the assumed earthquake on an urban area (Cochrane, 1975).

Adjustments to the Hazard

No significant differences exist between the nature of earthquake adjustments in the coastal zone and those for the country as a whole. Overall, eight types of adjustments are recognized.

1. Earthquake reduction
2. Earthquake resistant construction
3. Land use management
4. Earthquake insurance
5. Preparedness
6. Relief and rehabilitation
7. Prediction and warning
8. Reduction of associated hazards (Ayre, 1975).

The goal of earthquake reduction is to control the physical mechanism of earthquakes. Some people have suggested that triggering of small earthquakes by water injection will dissipate stress, thus possibly eliminating large, catastrophic earthquakes.

> It appears that the scientific and technological feasibility of accomplishing this is very remote and perhaps impossible. Responsibility for the damages caused by the "small" earthquakes also poses a formidable consideration. It is unlikely that earthquake reduction will be a viable option in the near future.

Earthquake resistant construction is applied in California and Massachusetts and is under consideration in Washington but has received scant attention in other coastal states. Its purpose is to protect human life and minimize damage from failures of buildings and other structures.

> An effective application of this adjustment requires: 1) development of technical design knowledge concerning performance of structures under varying seismic stress conditions; 2) development of acceptable regulations and codes that require application of earthquake resistant construction techniques in an equitable manner; and 3) insuring that codes are enforced and professional standards are upheld during construction.

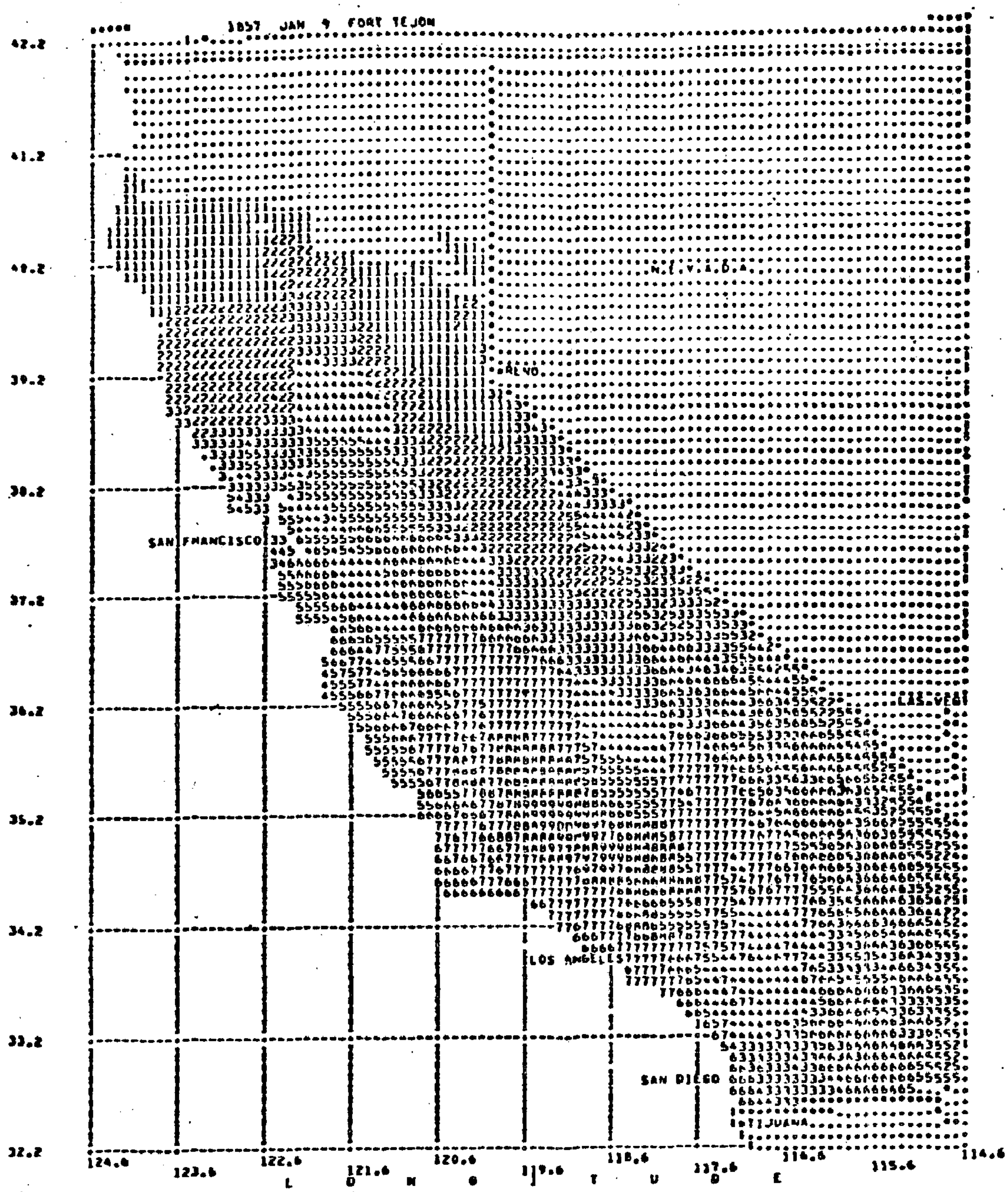


FIGURE II-16

COMPUTED EARTHSHOCK SEVERITY PATTERN OF 1857 FORT TEJON EARTHQUAKE IN SOUTHERN CALIFORNIA

(Friedman, 1976)

Building new structures which incorporate earthquake resistant design and construction features may cost approximately three to six per cent (3-6%) more than if resistant construction methods are not used. Modifying existing structures is more costly and less effective. The National Bureau of Standards (1973) and Whitman (1973) provide good discussions of the technical issues of earthquake resistant construction techniques.

Land use management works toward shaping the nature of development in hazardous areas through a variety of techniques such as subdivision regulation, zoning, and land acquisition (see section III on the range of adjustments).

> The use of this adjustment for earthquake mitigation is hampered by the difficulty of delimiting the hazard. Techniques are only now being developed to delineate earthquake risk on a micro-level to make land use control a practical tool.

However, the application of land use management to areas of potential ground failure in the coastal zone, as in the San Francisco Bay area, seems both feasible and desirable.

Earthquake insurance is available from private companies for residential and commercial structures throughout the entire coastal zone. This insurance is never included in a standard homeowners policy; it must be purchased separately. Even with its widespread availability, few policies have been sold, and most sales have been in California. In the west, a typical policy for a single-family frame house runs from $.15 to $.25 per $100.00 of annual coverage depending in which of the three risk zones the structure is located. All policies carry a five per cent (5%) deductible clause. These rates increase for more vulnerable types of construction. Insurance rates for large buildings are higher, and vary according to the specifics of building construction and location. In the east, a homeowner's policy would run between $.05 and $.10 and deduction clauses are optional.

> Insurance alone only redistributes losses; when tied to another adjustment such as earthquake resistant construction, an insurance program can reduce losses.

Most urban areas in the coastal zone have preparedness plans to be used in disaster situations. These plans usually have specific provisions for earthquakes or are applicable to all disasters.

> Unfortunately, preparedness plans seem to be quickly forgotten after preparation and may become outdated unless frequent and explicit measures are taken to call them to the attention of people concerned.

Relief and rehabilitation are widely accepted adjustments to earthquakes employed in the aftermath of a disaster. While a variety of post-disaster services are included under this heading, the most prominent is provision of relief funds to individuals, businesses and local governments.

> It does not appear that such efforts are effective in reducing losses. They may even increase loss potentials in the long run through diminishing the incentive to seek other means of damage reduction.

Earthquake prediction is a young science. So far the ability of seismologists to predict earthquakes accurately and consistently has not been demonstrated.

> If and when prediction becomes an accepted technology, it will be necessary to develop plans that make beneficial use of predictions and minimize adverse consequences.

Within the coastal zone one of the more attractive means of mitigating earthquake losses is reduction of associated hazards. For natural hazards triggered by seismic activity, including landslide, avalanche, and tsunami, mitigation measures described elsewhere in this report should be considered. Application of land use control regulating development seems to be the best means of reducing damages caused by soil liquefaction. Finally, a variety of actions aimed at reducing post-earthquake fire hazards can be very effective.

Federal Policies and Programs

The past role of the Federal government in earthquake matters has focused on preparedness planning, relief programs, and engineering, and seismic and geologic research.

During the 2nd session of the 94th Congress, legislature was introduced (Senate bill 1174) which would have provided for the establishment of a comprehensive earthquake mitigation and research program. Administrative responsibility was to be shared by the USGS and the National Science Foundation. The legislature was not enacted and the United States remains without a specific policy to deal with earthquake hazards.

The following Federal agencies are the principal ones currently linked with earthquake policy.

United States Geological Survey

The Earthquake Hazard Reduction Program of the USGS carries the major Federal responsibilities for earthquake related research in the field of earth sciences. This research is chiefly aimed at hazard reduction efforts. The major elements of the program are: hazard mapping and risk evaluation; earthquake prediction; earthquake modification and control; information and data sources; and earthquake engineering as a service to the National Science Foundation RANN program in earthquake engineering. (See Wallace, 1974 for a description of the program).

U.S. Geological Survey has recently established an earthquake prediction council to be responsible for reviewing data that could warn of an earthquake and recommending the issuance of a prediction. Council will consist of five USGS scientists and is the first Federal group of its kind to be established, marking a major step toward developing a system for the orderly and effective issuance of earthquake predictions.

Federal Disaster Assistance Administration

The FDAA does major work preparing and assisting in the development of preparedness plans. Money is made available to states under section 201 of the 1974 Disaster Relief Act Amendments (Public law 93-288) through this agency. The FDAA also assists in and coordinates post-disaster relief efforts.

Based on recent USGS analyses of potential impacts of serious earthquakes in Los Angeles, San Francisco and Seattle, FDAA is currently developing preparedness plans with other Federal agencies, as well as state and local officials in San Francisco and Seattle.

Federal Housing Administration and Small Business Administration

The FHA and SBA administer loans to homeowners and businesses damaged by an earthquake following a Presidential Declaration of a disaster. In the past up to $5,000 of these loans were forgiven, although current law (P.L. 93-288) eliminates the forgiveness clause and sets the interest rate at five per cent (5%).

National Science Foundation

NSF provides funding for a significant portion of the physical and social research relevant to earthquake mitigation.

National Bureau of Standards

The NBS is serving as the contract monitor for a project funded by NSF for the Applied Technology Council (ATC) to prepare a set of seismic design recommendations. ATC will conduct seismic risk studies and prepare a Design Regionalization Map. A final report is expected in June, 1977.

This agency also conducts the bulk of research on fire resistant construction and building codes.

At present, programs specific to the earthquake hazard are confined to the USGS and NSF. With new legislation, these agencies would continue their role in earthquake mitigation, and, hopefully bring coordination to Federal earthquake policy.

Experiences

Designing a building code ordinance in an objective and fair manner is one of the more difficult problems in earthquake mitigation. In most existing codes, earthquake provisions apply equally to all structures, not accounting for variations in function or exposure. Risk concepts are also seldom applied to the determination of code parameters. An exception to this is the Long Beach, California earthquake ordinance which acknowledges these problems (See Wiggins, 1971).

The principle behind the Long Beach code is to relate earthquake risk, based on the seismicity of the area, to other risks accepted in everyday life. As part of this process legislators choose the level of risk on which code parameters will be based. This "balanced risk" concept is one factor used in determining structural resistance requirements. The stringency of the code for particular structures is modified by the importance of the structure and its life expectancy. Thus, a more stringent earthquake resistant design is required for a highrise office building with a life expectancy of sixty years than for a warehouse with life expectancy of ten years.

This integrates economic consideration into the code. The methodology employed is of great importance because it reflects earthquake risk based on the seismicity of the area. Using this method, new codes can be designed for areas that are characterized by relatively low levels of risk, such as the eastern seaboard. In addition, this methodology is enhanced by current efforts to develop probabilistic risk maps. Refinement of this type of building code can and should be made for areas with outdated codes and those entirely lacking earthquake provisions.

The willingness of a community to consider the earthquake hazard is reflected in part by interest in building codes containing earthquake provision. An indicator of an individual's hazard appraisal is in the purchase of earthquake insurance. A recent study examining the decision to purchase insurance shows that the major factors in the choice are not economic considerations but relate to awareness of the earthquake problem, knowledge that insurance is available, experience with the hazard, and communication with persons already having earthquake insurance (Kunreuther, et al., 1976). Such findings indicate that the present earthquake insurance mechanism is inadequate.

G. Tsunami

Large gravity waves in the sea, associated with some very strong earthquakes and other impulsive disturbances, are referred to in international usage by the Japanese word, "tsunami." The term "seismic sea wave" is also used in some instances, and the inaccurate designation "tidal wave" still finds wide use. Cox (1963) defined tsunami as "a train of progressive long waves generated in the ocean or a small connected body of water by an impulsive disturbance." This definition does not include storm surges, astronomic tidal waves or seiches. Van Dorn (1966) has defined tsunami as "the gravity wave system formed in the sea following any large-scale, short duration disturbance of the free surface." Though tsunamis occur comparatively infrequently, they can cause almost complete devastation when they strike.

While the major risk from damaging tsunamis is along the Pacific coast of the continental states and Hawaii, destructive events can occur in the Atlantic where the hazard receives little attention.

Delineating the Hazard

It is convenient to distinguish between two types of tsunamis, major and local. Major tsunamis consist of a train of long period waves which spread out from the epicenter area, accelerate as they sweep through deeper ocean water, and are capable of causing damage to distant coasts (Berg et al., 1972). Tsunamis composed of trains of shorter period waves cause damage along relatively confined bodies of water and are generated locally by faulting or by rapid sliding or slumping of unconsolidated sediments at or below the water line (Cox, 1972a). Tsunami waves are much longer than ordinary waves from crest to crest, and have apparent periods varying from perhaps a quarter of an hour to a few hours. Local tsunami waves have a shorter period, from two to ten minutes (Van Heune and Cox, 1972). A major tsunami may cause damage to distant coasts several hours after it is generated. Local tsunamis strike suddenly. It should be stressed that a tsunami is comprised of a series of waves; the first is seldom the largest wave to arrive.

In mid-ocean tsunamis may have wave lengths of several hundred miles and heights of a foot or less. Hardly discernible in the open ocean, wave heights increase as coastal waters become more shallow and cause the waves to slow down. When a tsunami impinges on a distant coast, the water may rise and fall gradually or the waves may convert to bores with steep, turbulent fronts. The water may run to heights in excess of 50 feet on distant coasts. Local tsunamis may have even greater heights. One occurring in Alaska in 1958 at Lituya Bay had a run-up height of 1200 feet (Iida et al., 1967). Run-up height refers to the elevation above the tide level (at the time of the tsunami) reached by the waves as they inundate the land (Ayre, 1975).

Tsunami waves can travel hundred of miles per hour, speed being dependent upon the depth of the ocean. Given the location and time of the displacement and ocean depths between the epicenter and each coast, the arrival times for a major tsunami can thus be estimated.

Of direct importance for hazard management are the intensities of tsunamis in the management areas. Run-up heights are generally recorded as indicators of such intensities, and Bretschneider and Wybro (1975) have proposed an intensity scale, defined in terms of local run-up heights, which has potential value for planning.

At present, however, numerous unresolved questions prevent accurate prediction of tsunami run-up heights. This is due in part to the fact that run-up height is affected by numerous, complicated factors, which are, for the most part, non-coherent, energy-scattering offshore processes not amenable to calculation. The configuration of the coastline, shape of the ocean floor, and the character of advancing waves all play a role in determining run-up heights (Ayre, 1975). Wave height alone depends on a number of factors, such as earthquake magnitude, water depth at the epicenter, and earthquake focal depth (Bretschneider and Wybro, 1975). Additionally, Cox has found that tide stage may be a critical variable (1972b). Until these numerous factors and their interrelationships are better understood, predictions of run-up height will be weak at best.

The Potential Threat - The impact of a large tsunami can be devastating, depending on when and where it strikes. Within a few hours of the great Alaska earthquake in 1964, for example, catastrophic waves caused 103 deaths and $80 million in damages in Alaska, not including losses suffered at Port Alberni, British Columbia, and at Crescent City, California (Cox, 1972a).

The destructiveness of a tsunami may be attributable to the powerful surge of its wave front and to its rising and then falling sea level (Office of Emergency Preparedness, 1972). Much also depends on the nature of the waves as they approach the shoreline. If a tsunami wave breaks before it hits, the wave will behave like a bore and its momentum will be unleashed against anything in its path. If a bore has not formed, then the major impact will be the rapid increase and then decrease in hydrostatic pressure (Bretschneider and Wybro, 1975). Damage due to floating structures, debris, oil, and fires can also be anticipated.

Estimates of the number of Americans potentially endangered by Pacific tsunamis have been made based on the work of Eskite (1970). It appears from these estimates that over a million people are endangered. Classified as endangered by tsunamis of distant origin are those residing within one mile of the coast whose elevations are within fifty feet of sea level. Classified as endangered by tsunamis of local origin are those residing within one mile of the coast whose elevations are within 100 feet of sea level. Such a standard is admittedly much too broad and could result in overwarning. Moreover, it is not clear whether the definition refers to base of mean sea level or some other tide level.

Improvements in methods of vulnerability analysis are needed to speed up the task of mapping tsunami hazard areas. Identifying these areas must be accomplished before warning, evacuation, structural regulations, and land use controls can become effective.

These techniques may be appropriate for rough aggregate analysis, but they cannot be used for local risk analysis; for example, the number of people in any area varies by the time of day, day of the week, and season of the year. Land use controls, which could be used to channel new development and population growth into safer areas, must be based on finer measures of existing and potential risk. While some degree of risk from any hazard is acceptable, few communities have been able to make that level explicit for planning purposes.

Recent efforts by the Corps of Engineers to prepare flood and tsunami maps for the National Flood Insurance Program, administered by HUD, could soon provide the kind of information which is needed for this decision. Although not yet completed, the rate maps could be used for formulating local management boundaries, areas of particular concern, and use regulations.

Adjustments to the Hazard

Responsibility for hazard mitigation in the United States is divided among many Federal, state, and local agencies. Lack of organizational accountability and overlapping activities prevail, even within specific functional areas. Warning and evacuation, structural and design controls, land use controls, and relief and rehabilitation measures all have different objectives, needs and limitations. Community preparedness requires a wide range of measures, reactive and preventive, whose suitability will vary with local needs, values, capabilities, and previous experience with tsunamis and with the physical characteristics and location of the community. The tragedy is not that tsunamis occur, but rather that communities refuse to adjust, even when aware of the threat and then expect to be compensated for resulting losses.

The primary purpose of warning and evacuation is to save lives and some mobile property. Tsunami watches and warnings are issued to Civil Defense officials by the Honolulu Observatory, which is now part of the National Oceanic & Atmospheric Administration under the Department of Commerce. Warnings were first issued in the early 1920's by the Hawaii Volcano Observatory on the basis of seismographic information (Cox, 1968). In 1948 the Seismic Sea Wave Warning System was established. Warning coverage was extended to the National Warning System and to Civil defense agencies in California, Oregon and Washington by 1953, and to other Pacific countries in the 1950's, and to Alaska in 1962. Renamed the Tsunami Warning System in 1967, it became part of the International Tsunami Warning Center in Honolulu. The policy of selective cancellation of warnings based on mariegraphic confirmation was established in 1966, after problems with seemingly false warnings.

The Alaska Regional Warning System was founded in 1967, following the 1964 earthquake, to handle local tsunami problems (Cox and Stewart, 1972). In the early 1960's seismic trigger alarms were installed and are presently operated by the Weather Service. In addition, a similar state system is being installed by the Hawaiian Civil Defense. However, travel times may be so short for local tsunamis that formal warning systems may not be effective. Evacuation in the event of a local tsunami rests largely on individual recognition and initiative. (See Table II-6)

Responsibility for warning dissemination and public evacuation lies with state and county civil defense officials. While Federal support through the Defense Civil Preparedness Agency for civil defense personnel and equipment has been provided in the past on a matching basis, recent events suggest that federal funds for natural disaster-preparedness and planning cannot be assured.

> If warning and evacuation operations are to be effective in emergency, then risk areas must be defined, officials must be trained, plans must be updated, the warning must be disseminated, and the public must be motivated to respond.

Problems with tsunami prediction in the past have tended to reduce people's confidence in such systems. Overwarning, based on inadequate knowledge of the phenomenon, has led to false alarms and lack of compliance with warning attempts (Anderson, 1967; Cox and Stewart, 1972). Such lack of confidence and compliance undermines the effectiveness of the warning system (Lachman et al., 1961; Anderson, 1970). Haas (1971) has demonstrated that intensive short-term public education programs do not rectify the situation.

> Perceptions depend on length of residence, previous residence, and experience as well as personalities (Lachman et al., 1961).

Citizen awareness of natural cues stems from familiarity with local surroundings. In our mobile, transient society, local familiarity may be an unrealistic expectation.

In Hawaii, tsunami education programs are conducted in the public schools, maps of evacuation areas are printed in local telephone directories along with warning instructions, and special tsunami exercises and training sessions are held for local public officials. Unfortunately, such efforts may not be sufficient. Many will remain unaware of the danger or unwilling to follow directions.

Elsewhere in the United States successful evacuation will be much more difficult in the absence of such well developed education programs.

> It should be noted that a major constraint to successful management of this hazard is the rarity of large tsunamis, even in tsunami prone areas.

Of the 181 tsunamis recorded in the Pacific between 1900 and 1970, thirty-four were locally destructive, nine were destructive to both local and distant coasts, and 138 inflicted no damage or only minor

Table II-6

TSUNAMI SPEED OF ONSET, PHYSICAL CUES, EVACUATION TIME AND PREVENTIVE MEASURES

Speed of Onset Types	Physical Cues	Approximate Time For Evacuation	Preventive Action
I	yes (?)	Less than minute	Be very quick or dead
II	yes	5-10 minutes	The extent of death & injury in the community is a function of fast & appropriate response by individuals & leaders of small groups.
III	yes	15-30 minutes	Most persons will not be evacuated. Alert citizens & local officials may go to safe areas on their own initiative.
IV	no	45 min.-12 hrs.	Most persons can be evacuated and up to 75% of all "moveable" property

(Adapted from Haas & Trainer, 1973)

damage (OEP, 1972). Structural land use management measures may be necessary where large numbers of people reside, work, or visit.

In the past, Federal emphasis had been focused on relief and rehabilitation. Such an approach does not reduce casualties or property damages. Presently, FDAA assistance is complicated by bureaucratic stipulations and requires post-disaster damage assessment. Extension of the National Flood Insurance Act to cover tsunamis in 1973 was designed to redistribute losses and subsidize those who have adopted structural design controls.

> A very real problem is that insurance may encourage development in hazardous areas and thus magnify the cost of relief (Kunreuther, 1976). Without adequate knowledge of differential risk, rates will be inequitable and activities may be encouraged in what are really hazardous areas.

Responsibility for reducing property losses, and indirectly, casualties, through structural and land use controls remains with local government, where land use planning in the United States has traditionally been centered. Federal assistance to local planning agencies in the form of HUD grants and to states in the form of Coastal Zone Management Program grants has become increasingly important.

> However, much can still be done by federal agencies which hold land or regulate development along hazardous portions of the Pacific Coast where new growth is expected.

Naval and military installations, national recreation and conservation areas, federally subsidized sewage facilities, highways, harbors, and airports, urban renewal and redevelopment projects, federally regulated utilities, including nuclear power plants, and federally subsidized housing projects all help to determine the pace and direction of urban development.

> Introducing tsunami considerations into these locational and site decisions would have cumulative implications for development, which would hopefully result in major savings in the event of a large tsunami.

The effectiveness of possible mitigation measures has yet to be determined. Studies on the use of building codes, protective grove plantings, sea walls, and breakwaters in tsunami mitigation were largely restricted to Japan until 1960 (Cox, 1964). In addition to those measures previously mentioned, structural and design measures could include land filling, flood proofing, vertical zoning, emergency cutoffs in pipelines and criteria for designing shoreline facilities which could withstand or divert tsunami waves (Ayre, 1975). Such concepts could be incorporated into performance standards, building codes, subdivision regulations, and density bonus incentive systems. Storage tanks, air and highway terminals, and large public facilities, for example, could be restricted from designated hazard areas through conventional zoning regulations, transfer of development rights, land banking, environmental impact review, or preservation districts.

> But without better definitions of differential risk and the effectiveness of such controls, these measures will either be over or under designed. Coastal area management can insure that such risks will be thoroughly evaluated and implemented in a coordinated multi-agency program which extends beyond the usual incremental approach to planning.

Experiences

The General Plan of Hawaii County may be regarded as a pioneering effort in tsunami mitigation. Highly susceptible tsunami zones have been established. In such areas, development is excluded for all but those uses which cannot be located elsewhere on the island. It also requires criteria for development in less vulnerable areas of the Big Island. After lengthy debates about the efficacy of structural solutions proposed by the U.S. Army Corps of Engineers, authorized under the River and Harbor Acts of July 1960 and October 1962, and challenged by leading tsunami authorities, the City of Hilo, Hawaii has opted for redevelopment based on land use controls. The Hilo plan will retain 310 acres of bayfront in open space and concentrate its development on forty acres which have been elevated above the 1960 level of inundation. No protective works have been constructed in the United States exclusively for the purpose of tsunami protection, nor are any currently under consideration as offering feasible protection against tsunamis (PUSPP, 1976).

H. Volcano

Defining the Hazard

"A volcano is both the place and the opening from which molten rock or gas, and generally both, issues from the earth's interior onto the surface, and the hill or mountain built up around the opening by accumulation of rock material" (Macdonald, 1972). The ultimate origin of volcanoes is the rise of molten material through cracks or fissures in the earth's crust. The fundamental driving force behind volcanic eruptions appears to be the relative specific gravities of the liquid magma and the adjacent solid rock columns between the surface and the level of origin of the magma. An important additional driving force at relatively shallow depths is the expansion of gas, derived either from the magma itself or, less commonly, from steam produced by heated ground water. (Warrick, 1975).

Volcanoes differ widely in the nature of their eruptions, but can be generally classified into lava flow eruptions and pyroclastic eruptions. In situations where the magma is characteristically of low viscosity (usually basaltic), and there is a frequent release of pressure from expanding gases, the eruptions tend to be gentle and lava is the principal product erupted. On the other hand, if the magma is highly viscous (usually containing a higher percentage of silica), gases accumulate and are released at infrequent intervals, resulting in violent explosions in which the main product erupted is pyroclastic material consisting of fragments of magma or pre-existing rock material.

In addition, volcanoes differ in the frequency of their activity, and tend to be labeled "active", "dormant", or "extinct", depending largely on the evidence of past activity. The distinctions between these three relative categories are difficult to make, and the terms have often been used inconsistently in the volcano literature. Usually, the term "active" refers to volcanoes with certain or very probable records of eruption during historic times. The distinction between "dormant" and "extinct" is not easily made; especially during the later stages of their life cycles, the behavior of volcanoes is apt to be very erratic, with supposedly extinct volcanoes suddenly exploding into activity. Two of the most violent eruptions in the 20th century were from volcanoes thought to be extinct: Mt. Katmai, Alaska; and Bezmyannaya Sopka, Kamchatka (Tazieff, 1967).

Specific Hazards and their Effects

Their are a number of products or processes of volcanic activity that are hazardous to man and his environment. Some of these are directly related to volcanic eruptions: lava flows, pyroclastic flows, ash falls, volcanic mudflows, and toxic fumes. Still others--some mudflows, floods, forest fires, debris avalanches, and tsunamis--can be thought of as being indirectly attributable to volcanoes, and are often quite disastrous in their effects on man.

> Even though a particular phenomenon might occur independently of other events, it is most common to have various combinations of specific hazards during any one eruption, thereby compounding the hazardous effects on man.

Lava flows are streams of molten material on the surface of the earth, emitted from a vent of fissure. The form and speed of lava flows vary widely, depending upon the temperature and chemical composition of the magma, the rate of supply of magma to the flow, and external controls such as slope and nature of the terrain.

Lava flows are highly destructive, and can obliterate everything in their path. Since man habitually settles in valleys and low-lying areas, lava flows can pose a threat to buildings, agriculture, and other of man's activities. However, because of the relatively slow movement of lava flows, the threat to human life is extremely low (Warrick, 1975).

A pyroclastic flow is a turbulent mixture of inflated glass (derived directly from molten magma) and rock fragments suspended in gas that moves rapidly (over 60 mph) over the ground surface. The phenomenon is characteristically the product of violent volcanic explosions, especially associated with highly viscous magmas which have pushed up into the volcano and solidified to block the conduit (plug domes). A dense cloud of rock fragments and gas is ejected from the volcano (either laterally, from the side of the volcano, or vertically through the central vent) and behaves much like a heavy liquid.

Pyroclastic flows can be incredibly destructive. One of the best known catastrophes of this century was the result of such a flow. Mount Pelée on the island of Martinique erupted in 1902, destroying the town of St. Pierre in a matter of minutes and killing all but a few of its 30,000 inhabitants.

Like lava flows, pyroclastic flows tend to travel down valleys and drainage ways. Populations located in such valleys, especially close to the volcano itself, are particularly susceptible to the flow. Unlike lava flows, however, there is little chance for evacuation once the pyroclastic flow is generated (Warrick, 1975).

Ash Falls - Violent volcanic eruptions are apt to throw thousands of tons of rock fragments of varying sizes into the atmosphere. The distance traveled depends upon the magnitude of the eruption, the speed and direction of the wind, the size of the particles, and the degree of vesiculation. These smaller fragments are termed "ash".

The fallout of volcanic ash has a great diversity of hazardous effects. Health, buildings, transportation and communication, agriculture, vegetation, and climate can all be affected, to varying degrees, by ash falls. Besides the potentially harmful effects of the ash particle itself, there is the added effect of the gases released by the ash particles as they cool. Ash falls may contaminate water supplies, damage buildings and reduce visibility and therefore, transportation and mobility (Warrick, 1975).

A volcanic mudflow "represents a form of mass movement of sediment that is intermediate between a flood and an essentially dry landslide" (Waldron, 1967). It is a mixture of fine material and water; the relative proportions of water and sediment may vary greatly. Mudflows commonly contain volcanic ash, and may pick up coarse debris as they travel downslope. There are numerous causes of volcanic mudflows including the release of water in a crater lake, rapid melting of snow or ice, entrance of flows into streams, heavy rain, etc.

The speed and distance a volcanic mudflow travels may vary greatly, mainly dependent upon the magnitude of the event and the nature of the terrain over which it travels. Speeds of twenty to thirty miles per hour are common, and speeds in excess of sixty miles per hour have been recorded. A mudflow will frequently travel five to ten miles, although distances of greater than 100 miles have been attained (Macdonald, 1972). The huge Osceola mudflow that occurred about 5,000 years ago from Mt. Ranier, Washington, "traveled 40 miles down valley to the mountain front, then spread out in a lobate mass that covered 65 square miles in the Puget Sound lowland" (Crandell and Mullineaux, 1974).

Macdonald (1972) has stated that volcanic mudflows have probably destroyed more property, including arable land, than any other type of volcanic action within the last few centuries. The nature and areal extent of the destruction is similar to that of floods, except that a mudflow can bury everything in its path under tens or hundreds of feet of sediment. (Warrick, 1975).

Delineating The Hazard

Volcanoes are a definite and recurring coastal hazard in Alaska and Hawaii, and those in the Cascade Range pose at least a theoretical hazard to the coastal zone of Washington. There are some seventy-six volcanoes in Alaska, at least six in Hawaii of which five are on the island of Hawaii, and at least thirteen in the Cascade Range, two in California, six in Oregon, and five in Washington.

The Cascade and Alaskan volcanoes are andesitic and explosive. They have built up steep cones, and support glaciers and perennial snowfields, and are part of the circum-Pacific volcanic belt. The Hawaiian volcanoes are basaltic, with gently sloping cones, and are less violent and less dangerous to lives, than andesitic volcanoes (see figure II-17).

In Hawaii, Mauna Loa and Kilauea have been active in recent years and both Haleakala (on Maui) and Haulalai (on Hawaii) have each erupted once in historic times--around 1790 and 1800-1801, respectively. (Warrick, 1975). In Alaska there have been hundreds of eruptions of thirty-nine separate volcanoes during the short, 200 years, of recorded history.

There has been no eruptive activity in the Cascades since the Mt. Lassen Peak eruptions 1914-17, but unusual steaming activity has been observed on Mt. Baker, in northern Washington, since March 1975.

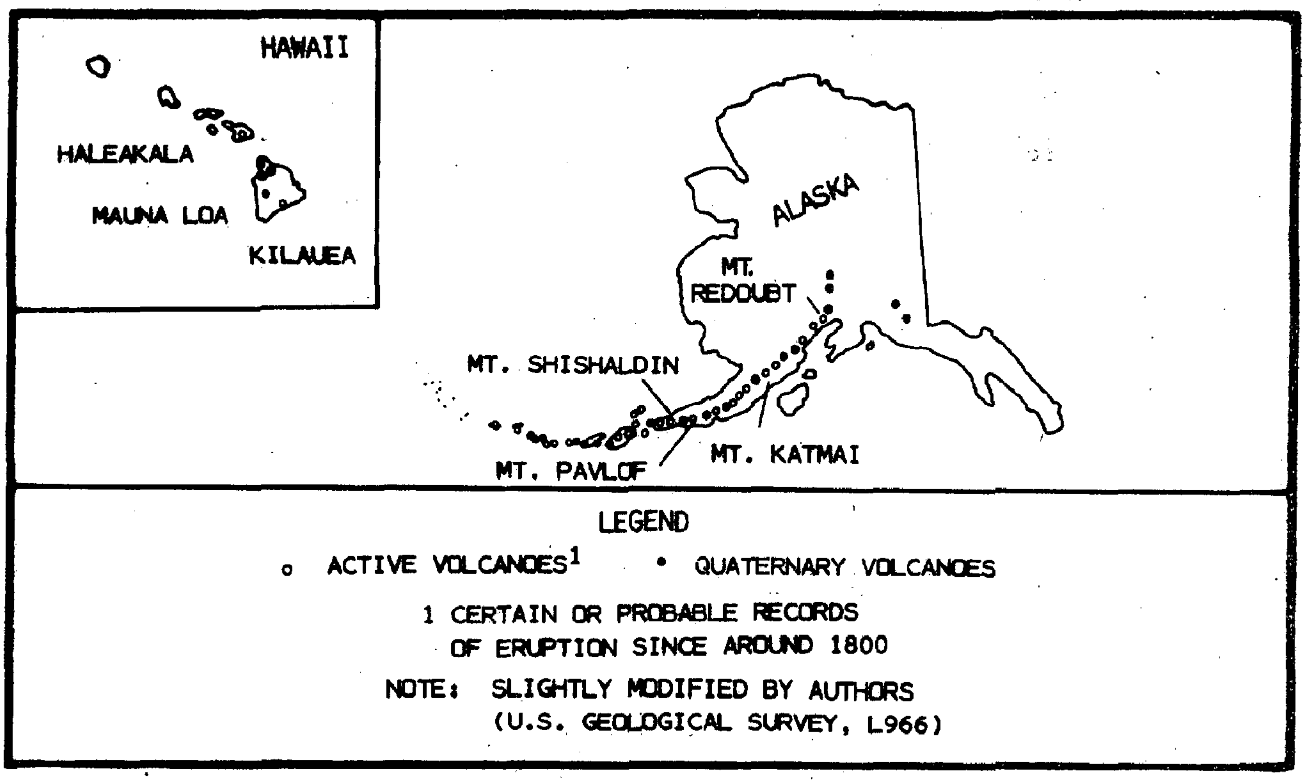
Hawaiian Volcanoes

The Hawaiian volcanoes, with their relatively calm outpouring of lava, pose little threat to life, but may damage or destroy crops and other vegetation, roads, buildings, and potentially, entire villages. Lava flows have reached the sea in numerous places during historic time, and an eruption on the northeast flank of Mauna Loa has threatened the island's main city, Hilo, on several occasions.

Adjustments to the Hazard in Hawaii

These frequent lava-type eruptions have permitted the development of relatively accurate methods of prediction and warning. The level of preparedness is generally high, and provisions for relief and rehabilitation.

detailed. The Hawaiian populace is aware of the lava flow hazard and, for the most part, knows what steps can be taken in the face of advancing lava flows (Murton & Shimabukuro, 1972). Bombing, to disrupt channels and tubes carrying flowing lava, and to redirect the lava flows, has been tried twice, 1935 and 1942, with inconclusive results. Diversion barriers involving a series of walls averaging about thirty feet in height, have been considered to protect Hilo, but not constructed. (During the eruption on the island of Heimaey in Iceland in 1973, temporary barriers made with bull-dozers and



VOLCANOES OF ALASKA AND HAWAII

FIGURE II-17

drenching of an advancing lava flow by seawater were credited with saving much of the town.)

Although authority exists both in local and state land use planning legislation, land use management with specific reference to the volcano hazard in Hawaii, has not been implemented.

The Hawaiian Volcano Observatory engages in research and monitoring, and issues primary warnings of eruptions. Further warning and evacuation, if necessary, are carried out by disaster agencies: police, fire departments, National Guard and Civil Defense. While agencies and populace are experienced with lava flows, they have no experience with violent eruptions.

Alaskan Volcanoes

The Alaskan volcanoes represent a substantial coastal hazard throughout much of the 1600-mile volcano belt stretching from near Anchorage to the tip of the Aleutians. Most are close to tidewater. During the 200 years of recorded Alaska history there have been some 250 separate eruptions at thirty-nine volcanoes. (Wilcox, 1959). The 1912 eruption of Katmai and Novarupta was the most violent experienced in Alaska during historic time, and one of the world's major eruptions.

The potential hazards run the gamut of volcanic risks, as follows:

1. Krakatoan type of eruptions
2. Directed blasts, nuees ardente (fiery cloud)
3. Pyroclastic flows
4. Lava flows
5. Volcanic mudflows
6. Turbulent hot ash clouds associated with pyroclastic flows
7. Explosive blasts and associated rock falls
8. Ash falls
9. Corrosive rains - volcanic gas
10. Flash floods
11. Break-out of ice dammed lakes
12. Lightning discharges
13. Seawaves
14. Volcanic earthquakes. (modified from U.S. Army Corps of Eng., 1972).

Most of the Alaskan volcanoes are too remote from populated places to be significant threats except from ashfall and seawaves, but at least four Aleutian communities, Akutan, Atka, Cape Sarichef, and False Pass, are close enough to face the entire range of volcanic effects. The Cook Inlet volcanoes, notably Augustine, Redoubt, Iliamna, and Spurr, endanger shoreline installations with mudflows, floods, and ashfall, and many communities over a wide area are threatened by ashfall, seawaves, and corrosive precipitation. Very large seawaves are probably the greatest single and most widespread hazard to lives and property. Augustine created a seawave in 1883 reported to be twenty or more feet in height at English Bay on the Kenai Peninsula; fortunately, the tide was low and no lives were lost.

Adjustments to the Hazard in Alaska

While progress on the prediction of volcanic activity is promising, the specificity needed for successful prediction of volcano-generated seawaves is not available. At present, Augustine is the only volcano in the region which is under continuous seismic surveillance, but even this is subject to interruption by volcanic activity when most needed.

> More research is needed on the relationship between volcanic, seismic, and seawave activity. Also, more consideration should be given to optimal siting of shore facilities and settlements, and the development of protective technology for shoreside installations.

A promising adjustment, developed following the 1964 earthquake and tsunami, is the physical separation of facilities to reduce the chance that an entire community will be destroyed or disabled.

In general, the adoption of surveillance and monitoring techniques and the development of predictive methods have been slow, due in part to the physical nature of the volcanic activity in Alaska. Disaster preparedness with specific reference to the threat has been negligible. Unfortunately, the threat of a disaster which has a low probability of occurrence, is little understood and for which there is meager historical experience, is most typically met with complacency (Warrick, 1975).

Cascade Volcanoes

Although relatively remote from coastal areas, the Cascade volcanoes are explosive and have the potential for creating mudflows, lava flows, pyroclastic flows and volcanic ash. Theoreticlaly, Mt. Rainier could pose a threat to the populous shoreline zone from mudflows and floods flowing into the valleys of the White, Nisqually and Puyallup rivers and their tributaries. The situation in the White and Nisqually river valleys is complicated by the presence of reservoirs, which could either help or exacerbate the problem. Evidence of geologically recent mudflows has been found, the most recent about 500 years ago which reached within about twelve miles of tidewater near Tacoma (Coombs, et al., 1974). Ashfall might also affect the Puget Sound lowland, but the prevailing winds generally carry ash to the eastward.

The mudflow/flood threat is a low probability event, but one with potential for great disaster should it occur. This hazard admits of little in the way of adjustment to protect lives and property. The level land afforded by floodplains is at a premium in the Puget Sound lowland for agricultural, industrial, and commercial uses, and under any application of the concept of balanced risk, will continue to be used with increasing intensity.

In short, the Cascade volcanoes represent a potential threat in their immediate vicinity, but the probability of their impacting the shoreline zone is so low that it militates against considering them significant coastal hazards.

I. Avalanche

Defining the Hazard

An avalanche is a moving mass of snow or ice located in an arctic, alpine or sub-alpine region, usually accelerating as it flows down a steep mountainside until a gentle gradient is reached. Natural configurations of a slope hinder or increase its length and velocity, while atmospheric and physical processes within the snow cover determine its type. The technical categories for classifying avalanches are generic and morphological. The destructive potential of avalanches is determined by the presence of people, structures, and accompanying development in the paths (Staff Members, 1975).

Snow avalanches are a common hazard throughout the mountainous terrain of the temperate and arctic regions and may occur wherever snow is deposited on slopes steeper than about 20°. They occur most often in the western United States and Alaska, but are a coastal hazard in Alaska alone, where mountains and sea meet in many places. In Alaska an abnormally high proportion of the population is at risk because the heaviest population concentrations are located along the coast where avalanches are common.

Avalanches in Alaska tend to be powerful due to the large scale of the topography which provides large catchment areas and long, glacially over-steepened slopes, extremely heavy winter snowfall, and violent winds. The violent nature of the Alaskan weather complicates data collection and monitoring activities which are necessary for accurate avalanche prediction.

Delimiting the Hazard

Mapping of avalanche hazard areas is technically feasible; however, costs involved are very high, especially in unsurveyed areas. An average United States Geological Survey 7½ minute quadrangle map (1:24,000 scale)requires an initial average investment of approximately $200,000 (Staff Members, 1975). In addition, Mears (1975) has pointed out that such a map is not adequate for providing detailed site specific information, but provides only a general indication of the avalanche hazard zone boundaries.

Experimental survey techniques are now being tested throughout the country. Efforts testing the potential for delimiting avalanche zones using high altitude multi-spectrum imagery are currently under study with the support of the National Aeronautics and Space Administration. In the more remote areas, the most feasible approach for hazard zone identification seems to lie in reconnaissance level surveys.

Most avalanche hazard zones can be recognized from vegetation patterns and other visible effects of past scouring, except where manipulation of vegetation may have erased the obvious traces. Moreover, as with floods, there is always the chance that a larger event than any indicated by existing evidence will occur. There is also the remote possibility that unusual circumstances, such as the combination of heavy snow accumulation with a large triggering earthquake, can cause avalanches on virgin slopes. The science of avalanche dynamics and terrain analysis is at best inexact. Estimates of runout zone boundaries, frequencies, and impact pressures are qualitative, and therefore, subject to an undefinable degree of uncertainty (Mears, 1976).

Along the extremely hazardous south and southeastern Alaska region, meteorological data of many years' accumulation were lacking, as was the determination of avalanche tracks, until the earthquake of March 1964 struck and triggered thousands of snowslides. This single event provided information on avalanche activity which would have taken approximately fifty years of observation to duplicate. Such information will be valuable to planners and engineers in the development of Alaskan highway, railroad and power transmission systems. (LaChapelle, 1968).

Adjustments to the Hazard

Adjustments to avalanche hazard fall into several categories: structural controls, reforestation and afforestation, prediction and warning, artificial release, land use management and highway protection. These approaches vary in usefulness, cost and effectiveness; effectiveness not always related to cost. None of these adjustments should be considered as providing complete security.

Alaskan avalanches, by their large and powerful nature, are less amenable to management by defensive measures, such as controlled release, catchment zone treatment to inhibit formation, or structures to protect lives and property in the slide zone. Land use management techniques are also less effective for mitigating avalanche hazards in Alaska. This results from the intense competition for the extremely limited amount of suitable land along the coast.

Coastal avalanches may generate additional hazards, such as destructive sea waves. And, conversely, avalanches may themselves be the side effect of other natural hazards, i.e., earthquake, a frequent hazard along the southern Alaskan coast.

Despite the threat to life and property that avalanches pose in some Alaskan coastal locations, most occur harmlessly in remote places. The casualty rate is low: eleven fatalities during the period 1950 to 1975. (Staff Members, 1975).

> As a result, the avalanche problem is accorded low priority and there appears to be little willingness to incur the social costs involved in providing a margin of safety by condemnation and compensation proceedings in those areas that face a potential avalanche hazard to life (see section on Alaska).

The management problem is further hindered by diffused authority and inability to predict extreme events. The Forest Service has available expertise, but no authority outside the national forest boundaries. Highway maintenance personnel often have extensive experience, but generally do not exercise authority to close highways in advance of slides. Local jurisdictions, which have the authority for exercising land use controls, are reluctant to seek information and impose controls, especially retroactively. In short, the potential for disaster mounts.

Experiences

Juneau, located on the southeast coast of Alaska, nestled between steep mountains on the east and the ocean channel to the west, is presently experiencing growth and expansion into the avalanche hazard zone. Attempts to assess the hazard in detail and to identify possible alternative adjustments, including land use management zoning, have recently begun. An intensive study, in 1972, of the total geophysical hazard situation urged zoning ordinances for the identified hazard zones. As yet, much debate and consideration have been given the proposal, but adoption of hazard zoning has not resulted (Staff Members, 1975).

J. Land Subsidence

Unlike most natural hazards which are instantaneous events, land subsidence is usually a gradual process which can occur over periods of several decades. However, in some circumstances, subsidence can precipitate instantaneous events such as dam or levee failure along with their dramatic consequences. In most cases, the direct hazard presented by subsidence is economic loss rather than a threat to human life.

Although most states experience subsidence problems, only Alabama, California, Florida, Illinois, Louisiana, Michigan, New Jersey, New York Ohio, Pennsylvania, Texas and Washington have encountered this hazard in their coastal areas.

Defining the Hazard

Land or ground surface subsidence is the relative sinking of the earth's crust in limited areas. There are several major causes of subsidence, including withdrawal of fluids (oil, gas or water), underground solution or erosion of rocks, lateral flow of earth materials (e.g. clay) under loading, drainage of peat lands, extraction of solids in traditional or solution mining operations, hydrocompaction, tectonic movements and volcanic activity.

Of these processes, the most significant in the coastal zone of the western states, Louisiana, Florida, and Texas, seem to be fluid withdrawals, hydrocompaction, and drainage of peat lands. However, in the northeastern and Great Lakes states the problems of subsidence seem more closely related to extraction of solids.

Subsidence due to fluid withdrawal can generally be broken down into two main classes: 1) withdrawal of oil or gas, and 2) withdrawal of ground-water. In both of these cases, the effect is the same. Reducing underground pressure in the aquifers increases the effective stress on the aquifer structure.

Drainage of areas of organic deposits (e.g. peat) represents another major cause of subsidence of coastal lands. Drainage, usually for agricultural purposes, results in oxidation of the deposits (mainly by aerobic bacteria), compaction by tillage machinery, burning, shrinkage due to drying, and finally wind erosion; all lead to surface subsidence. In general, the subsidence rates are correlated with groundwater depths; the lower the water table, the greater the subsidence (Cooke & Doornkamp, 1974).

Hydrocompaction, subsidence resulting from the wetting and compaction of certain types of surface sediments, usually occurs in areas having moisture-deficient, open-textured sediments. When these deposits are wetted for the first time, as with irrigation, or when the overburden load is significantly increased, the intergranular strength of the deposits is weakened, rapid compaction occurs, and ground-surface subsidence follows (Lofgren, 1969).

Of particular importance in the Great Lakes states is the removal of solids through traditional mining (e.g. coal), or solution mining operations (e.g. sulphur or salt). The precise extent of the subsidence zone and the nature of the subsidence is variable and dependent upon such factors as the form of the mining, the thickness of the seam, and the thickness and composition of the overlying strata.

Several of the other processes mentioned above contribute to relatively minor and somewhat more localized subsidence problems in coastal areas, e.g. limestone sinkholes and tectonic induced subsidence. The city of Kodiak, Alaska, for example, has suffered damage resulting from earthquake-induced land subsidence. The unpredictable nature of these events makes planning for their occurrence difficult or impossible.

Delineating the Hazard

Because subsidence is often a slow process in which ground levels may fall at very slow rates, and over extended periods of time, exacting methods of measurement must be employed to monitor the changes. The most widely used method is that of repeatedly surveying by leveling a series of precisely located benchmarks or other points of known relative altitude. A second means is the direct measurement of compaction through the use of a compaction recorder.

The delineation of areas of potential long term or instantaneous subsidence where removal of solids at depth has taken place can be accomplished through sonic techniques. Although this method is quite practicable, little effort has been made in this direction to date.

The benchmark method can be employed over large areas, but the costs can be high. It has been estimated that first-order leveling costs approximately $200 per mile and second-order leveling about $100 per mile (Poland, 1969). The recorder method, on the other hand, is only of use at a single site.

Problems Caused by Subsidence

The most obvious and extensive consequence in coastal zones is the loss of low-lying lands through submergence. Of equal potential import is the increased amount of land exposed to flooding from hurricane storm surge or stream runoff. If storm tides of the same magnitude as those generated by Hurricane Carla (1961) had struck upper Galveston Bay in 1974 an additional seventy square miles of subsided land would have been inundated. (Brown, et al., 1974).

Differential changes in elevation in subsiding areas also create problems in construction and maintenance of canals, irrigation ditches, sewage systems, and stream-channel grade.

In the extreme, instantaneous subsidence events, such as those occurring over mined areas, can cause injuries or death. Although, the threat to human safety is not nearly as great as the likelihood of economic loss, the high density development of potentially subsiding lands increases this possibility steadily.

Adjustments to the Hazard

In areas where extensive fluid withdrawal has occurred, the most effective corrective measure has been repressuring the area through injection of a substitute fluid (usually sea water). Although this method has proved efficacious, it is quite costly. Salt water has been injected into the ground underlying the Wilmington oil field in Long Beach, California at the rate of 1,000,000 barrels per day since 1965 (Detwyler, 1971).

Some of the other causes of subsidence generate coping methods which are specifically oriented to that type of subsidence. Thus, the wetting of sediments prior to development of lands subject to hydrocompaction subsidence allows compaction to take place without risk of property damage.

The measures employed to cope with areas where solids have been removed are similar to those used in reducing subsidence from fluid removal, i.e. the underground spaces are refilled either with solids (e.g. tailings) or with solutions.

Other responses to subsidence in coastal areas include the construction of works to protect against the inundation of the subsided lands, continuous repair of facilities in the affected areas, and land use regulations.

Federal Policy and Programs

> At present, no national policy deals with land subsidence. However, because of the widespread nature of this hazard, such a policy seems needed.

Justification for a subsidence warning program lies in the Disaster Relief Act of 1974 which declares the need for disaster warnings with respect to earthquakes, landslides, and "other geologic catastrophes." (Sec. 202, 88 Stat. 143, 42 U.S.C. 5121.)

Few subsidence studies have been undertaken at the Federal level. The U.S. Geological Survey (USGS) has studied problems of fluid withdrawal subsidence, and both the USGS and the Bureau of Reclamation have looked into questions of hydrocompaction subsidence.

Experiences

Long Beach, California - One of the more dramatic examples of subsidence problems occurred in the Long Beach area of California where subsidence as a result of fluid withdrawal in the Wilmington oil field has probably been greater than such subsidence anywhere else in the world. From 1928-1971 the maximum vertical subsidence was nearly thirty feet, and covered an area of more than twenty five square miles. The rate of subsidence has varied greatly over the years but equaled thirty-nine per cent (39%) of the total volume of fluid removed (Poland and Davis, 1969).

Because the area originally was only five to ten feet above sea level, extensive remedial measures were taken to prevent the heavily industrialized facilities from being inundated by sea water. Repair, maintenance and mitigation efforts were extremely costly, exceeding $100 million by 1962 (Poland, 1969).

The repressuring of the area has proved to be quite effective in arresting subsidence over a large part of the area, and a small amount of surface rebound has occurred in the areas of heaviest injection. (Mayuga & Allen, 1966). Costs had reached $30 million by 1969 (Poland and Davis, 1969).

The City of Long Beach maintains a constant surveillance of the area through a series of benchmarks. Reservoir pressures are monitored and tidal gauges are read on the drilling islands off Long Beach to aid in subsidence detection.

Houston-Galveston Area, Texas - During and following the Second World War, this area experienced very rapid industrial development, and consequent demands upon water were met mainly through the exploitation of aquifers. Heavy withdrawals of water resulted in the decline of artesian pressure head, and the rate of water level decline increased from 1.21 meters per annum from 1954-9 to about 2.13 meters per annum from 1959-64 (Gabrysch, 1969).

Subsidence began prior to World War II, but has been precisely monitored by a network of leveling stations only since 1943. Subsidence rates from that time to the present have a high correlation with groundwater pumping rates and the lowering of the water pressure in the aquifers. It has been pointed out that the area affected by subsidence of at least one foot doubled approximately each decade since 1943 (Brown, et al, 1974). In all, more than 3,000 square miles of Texas coastal land have subsided at least one foot. Because of the clay composition of the aquifers, even if groundwater pumping were stopped immediately, the compaction and subsidence process would probably continue long enough to cause an estimated fifteen to twenty percent additional ground lowering (Texas General Land Office, 1976).

Mitigation of the impact already experienced and reduction of future subsidence effects can only be accomplished by vacating the affected areas or by constructing protective structures. The Corps of Engineers has investigated the possibility of constructing an extensive hurricane barrier system across the southern end of Galveston Bay (Brown, et al., 1974). Engineering works cannot assure long-term protection unless further subsidence is prevented.

REFERENCES

American Shore and Beach Preservation Association, Newsletter, March 31, 1970.

Algermissen, S.T. and D.M. Perkins, A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States. U.S. Geological Survey, Open-file Report 76-416.

Anderson, William A., "Tsunami Warning in Crescent City, California, and Hilo, Hawaii." The Great Alaska Earthquake of 1964: Human Ecology. Washington, D.C.: National Academy of Sciences, 1970, pp. 116-124.

Ayre, Robert S., Earthquake and Tsunami Hazards in the United States: A Research Assessment. Boulder: Institute of Behavioral Science, University of Colorado, 1975.

Baker, E.J., J.C. Brigham, J.A. Paredes, and D.D. Smith, Social Impact of Hurricane Eloise on Panama City, Florida. Technical Paper No. 1. Tallahassee: Florida Resources and Environmental Analysis Center, 1976.

Blanc, Robert P. and George B. Cleveland, "Geological and Slope Stability Maps of the San Clemente Area, Orange and San Diego Counties, California." California Department of Conservation, Division of Mines and Geology, Special Report 98, plate 1, 1968.

Brabb, E.E., E.H. Pampeyan and M.G. Bonilla, "Landslide Susceptibility in San Mateo County, California." San Francisco Bay Region Environment and Resources Planning Study, U.S. Geological Survey Miscellaneous Field Studies, Map MF-360, 1972.

Berg, Eduard, et al., "Source of the Major Tsunami." The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering. Washington, D.C.: National Academy of Sciences, 1972, pp. 122-138.

Bird, Neale, Handbook for Coastal Property Owners. South Carolina Sea Grant Marine Advisory Bulletin No. 10, 1975.

Brater, Ernest F., John M. Armstrong and Michael McGill, Michigan's Demonstration Erosion Control Program, Update Evaluation Report. Lansing: Michigan Department of Natural Resources, 1975.

Bretschneider, Charles L. and Pieter G. Wybro, Inundations and Forces Caused by Tsunamis for the State of Hawaii. Technical Supplement No. 5, Hawaii Coastal Zone Management Program. Pacific Urban Studies and Planning Program, University of Hawaii, 1975.

Brinkmann, Waltraud A.R., Severe Local Storm Hazard in the United States: A Research Assessment. University of Colorado, Boulder, 1975.

Brown, L.F., Jr., et al., Natural Hazards of the Texas Coastal Zone. Bureau of Economic Geology, University of Texas at Austin in cooperation with the Texas Coastal and Marine Council, 1974.

Bruun, Per, "Beach Erosion and Coastal Protection." In Rhodes W. Fairbridge, ed. Encyclopedia of Geomorphology. New York: Van Nostrand Reinhold, 1968.

———————, "Coastal Development and Coastal Protection," Engineering Progress at the University of Florida. Vol. 9, Bulletin Series #76. Gainesville: University of Florida, 1955.

Carney, Charles and Albert Hardy, North Carolina Hurricanes. Environmental Science Services Administration. Washington: U.S. Department of Commerce, 1967.

Carroll, Allen, Developer's Handbook. State of Connecticut, Department of Environmental Protection, Coastal Area Management Program, 1975.

Clark, Gilbert, National Hurricane Center, Associated Press Release, October 10, 1975.

Coastal Zone Resources Corporation, A Study to Assess Goals for Uses and Management of Shoreline and Implications for Corps of Engineers Programs. Report to the U.S. Army Corps of Engineer Institute for Water Resources, Fort Belvoir, Virginia, IWR Contract Report 75-4, 1975.

Cochrane, H.C., "Predicting the Economic Impact of Earthquakes." Natural Hazard Working Paper #25. Boulder: Institute of Behavioral Science, University of Colorado, 1975.

Colon, J.A., "Some Aspects of Hurricane Carla, 1961." Hurricane Symposium. American Society for Oceanography Publication #1, pp. 1-33.

Cooke, R.V. and J.C. Doornkamp, Geomorphology in Environmental Management. Oxford: Clarendon Press, 1974.

Coombs, Howard A., et al., Report of the Ad Hoc Committee on Geologic Hazards to the Washington State Legislature (1975 Session) by a committee appointed by the Senate Committee on Commerce, December, 1974.

Cox, Doak C.,"Status of Tsunami Knowledge". Proceedings of the Tenth Pacific Science Congress, Honolulu, Hawaii, August-September, 1961. Doak C. Cox, Editor. IUGG Monograph 24, Paris, 1964, pp. 1-6.

______________, Tsunami Research in Japan and the United States. Studies in Oceanography, pp. 403-412 (Hawaii Institute of Geophysics Contribution No. 64), 1964.

______________, Performance of the Seismic Sea Wave Warning System, 1948-1967. Prepared for the State of Hawaii, Report HIG-68-2, Hawaii Institute of Geophysics, 1968.

______________, "Introduction to Part II: Tsunamis." The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering. Washington, D.C.: National Academy of Sciences, 1972, pp. 31-37.

______________, "Review of the Tsunamis." The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering. Washington, D.C.: National Academy of Sciences, 1972a, pp. 354-360.

Cox, Doak C. and Harris B. Steward, Jr., "Technical Evaluation of the Seismic Sea Wave Warning System." The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering. Washington, D.C.: National Academy of Sciences, 1972b, pp. 229-245.

Crandell, Dwight R. and Donal R. Mullineaux, "Appraising Volcanic Hazards of the Cascade Range of the Northwestern United States." Earthquake Information Bulletin 6 (No. 5, September - October). Reston, Virginia: U.S. Geological Survey, 1974, pp. 3-10.

Detwyler, Thomas R., Man's Impact on Environment. New York: McGraw-Hill Book Company, 1971.

Dolan, Robert, Paul J. Godfrey and William E. Odum, "Man's Impact on the Barrier Islands of North Carolina," American Scientist, Vol. 61 (March-April, 1973), pp. 152-166.

Emery, K.O., Progress in Oceanography: The Quaternary History of the Ocean Basins, Vol. 4. New York: Pergamon Press, 1967.

Eskite, Wilbur H., Jr., Analysis of ESSA Activities Related to Tsunami Warnings. A report prepared for NOAA Office of Plans and Programs, 1970.

Friedman, D.G., The Storm Surge Along the Gulf and South Atlantic Coastlines. Hartford, CT: The Travelers Insurance Company, 1971.

______________, Letter to Robert W. Kates. Hartford, CT: The Travelers Insurance Company, May 22, 1972.

______________, Computer Simulation in Natural Hazard Assessment. Boulder: Program of Research on Technology, Environment and Man, Institute of Behavioral Science, University of Colorado, 1976.

Gabrysch, R.K. "Land Surface Subsidence in the Houston-Galveston Region, Texas." Tokyo, Japan: International Symposium on Land Subsidence, Proceedings, pp. 43-54, 1969.

Great Lakes Basin Commission, Relocation and Public Acquisition Alternatives for the Reduction of Shoreland Damages: A Benefit-Cost Study, Monroe County, Michigan. Report for the FRC/CLBC Joint Task Force on Shoreland Damage Reduction, 1976.

Haas, J. Eugene & Patricia Trainer, "Effectiveness of the Tsunami Warning System in Selected Coastal Towns in Alaska." Paper presented at the Fifth World Conference on Earthquake Engineering, Rome, Italy, 1973.

Hebert, P. J. and G. Taylor, Hurricane Experience Levels of Coastal County Populations. Texas to Maine. National Oceanic and Atmospheric Administration, NWS, U.S. Dept. of Commerce, 1975.

Hicks, Steacy D., "Long Period Variations in Secular Sea Level Trends," Shore and Beach, Vol. 36 (1968), pp. 32-35.

Iida, Kumizi, Doak C. Cox and George Pararas-Carayannis, Preliminary Catalogue of Tsunamis Occurring in the Pacific Ocean. Prepared for the State of Hawaii and the Office of Naval Research. Data Report No. 5, Hawaii Institute of Geophysics, 1967.

Inman, D.L. and B. Brush, "The Coastal Challenge," Science, Vol. 181 (July 6, 1973), pp. 20-33.

Joint Federal Regional Council - Great Lakes Basin Commission Task Force, A Strategy for Great Lakes Shoreland Damage Reduction, Chicago, 1974.

Kunreuther, H., et al., Limited Knowledge and Insurance Protection: Implications for Natural Hazard Policy. Unpublished draft, 1976.

LaChappelle, Edward R., "The Character of Snow Avalanching Induced by the Alaska Earthquake". Pages 355-361 in The Great Alaska Earthquake of 1964: Hydrology, Part A. Washington: National Academy of Sciences, National Research Council, 1968.

Lachman, Roy, Maurice Tatsuoka, and William J. Bonk, "Human Behavior During the Tsunami of May 1960," Science, Vol. 133, No. 3462, pp. 1405-1409, 1961.

Lofgren, B.E., "Land Subsidence Due to the Application of Water," Reviews of Engineering Geology, Vol. 2, 1969, pp. 271-303.

Macdonald, Gordon A., Volcanoes. Englewood Cliffs, N.J.: Prentice-Hall, 1972.

Mader, G.G. and D.F. Crowder, "An Experiment Using Geology for City Planning - The Experience of the Small Community of Portola, California." Pages 177-189 in D.N. Nichols and C.C. Campbell, eds., Environmental Planning and Geology. Washington: U.S. Government Printing Office, 1969.

Mayuga, M.N. and D.R. Allen, "Long Beach Subsidence." in Ronald W. Tank, ed., Focus on Environmental Geology, pp. 347-352. London: Oxford University Press, 1973.

Mears, Arthur I., Snow Avalanches of the Vail Area, Eagle County, Colorado. Open File Report, Colorado Geological Survey, Department of Natural Resources, State of Colorado, 1975.

______________, "Guidelines and Methods for Detailed Snow Avalanche Hazard Investigations in Colorado." Colorado Geological Survey Bulletin 38, 1976.

Michigan Coastal Zone Laboratory, "Great Lakes Basin Commission Recession Rate Workshop Proceedings." Ann Arbor: University of Michigan, 1976. Suggests that coastal erosion figures for Great Lakes as reported in Table II-4 are greatly underestimated.

Mileti, Dennis S., Natural Hazard Warning Systems in the United States: A Research Assessment. Boulder: Institute of Behavioral Science, University of Colorado, 1975.

_________________, Disaster Relief and Rehabilitation in the United States: A Research Assessment. Program on Technology, Environment and Man, Monograph #NSF-RA-E-75-009. Boulder: Institute of Behavioral Science, University of Colorado, 1975a.

Miller, H. Crane, "Coastal Flood Plain Management and the National Flood Insurance Program: A Case Study of Three Rhode Island Communities," Environmental Comment, November 1975, pp. 2-14.

Moberly, Ralph, J. Frisbee Campbell and William T. Coulbourn, Offshore and Other Sand Resources for Oahu, Hawaii. UNIHI - SEAGRANT - TR-75-03, University of Hawaii, 1975.

Murton, Brian J. and Shinzo Shimabukuro, Human Adjustment to Volcanic Hazard in Puna District, Hawaii. IGUC Committee on Man & Environment paper, University of Hawaii, 1972.

National Bureau of Standards, Building Practices for Disaster Mitigation. NBS Building Series #46, U.S. Department of Commerce, Washington, D.C.: U.S. Government Printing Office, 1973.

National Oceanic and Atmospheric Administration, Flood Insurance Studies: (1) Brevard County, Florida; (2) Volusia County, Florida. Reports prepared for the Federal Insurance Administration of the U.S. Department of Housing and Urban Development. Rockville, Maryland: U.S. Department of Commerce, 1971.

________________, Project Stormfury 1972. Washington, D.C.: Department of Commerce, 1972.

________________, Flood Insurance Studies: (1) St. Johns County, Florida; (2) Palm Beach County, Florida; (3) Broward County, Florida. Reports prepared for the Federal Insurance Administration of the U.S. Department of Commerce, 1972a.

________________, Flood Insurance Studies: (1) City of Fernandina Beach, Nassau County, Florida; (2) Martin County, Florida; (3) Duval County, Florida; (4) Indian River County, Florida. Reports prepared for the Federal Insurance Administration of the U.S. Department of Housing and Urban Development. Rockville, Maryland: U.S. Department of Commerce, 1973.

________________, Flood Insurance Studies: (1) Charleston County, South Carolina; (2) Land Subsidence--Houston-Galveston, Texas Area; (3) Puerto Rico. Reports prepared for the Federal Insurance Administration of the U.S. Department of Housing and Urban Development. Rockville, Maryland: U.S. Department of Commerce, 1973a.

New Jersey Board of Commerce and Navigation, Report on the Erosion and Protection of New Jersey Beaches. Trenton, 1922.

Nilson, T. H. and E. E. Brabb, "Preliminary Photointerpretation and Damage Maps of Landslide and Other Surficial Deposits in Northeastern San Jose, Santa Clara County of California." U.S. Geological Survey Miscellaneous Field Studies, Map MF-361, 1972.

Nolan, K. M., D. R. Harden, and S. M. Colman, "Erosional Landform Map of the Redwood Creek Drainage Basin, Humboldt County, California--1947-1974." U.S. Geological Survey, Water Resources Investigations 76-42, Open File Report, 1976.

Office of Emergency Preparedness, Disaster Preparedness, Vols. 1, 2 and 3, Executive Office of the President, Washington, D.C.: U.S. Government Printing Office, 1972.

Pacific Urban Studies and Planning Program, "Tsunami and Storm Wave Hazards and Freshwater Flooding Hazards." Recommendation memo. Hawaii Coastal Zone Management Program, 1976.

Pilkey, O. H., Jr., O. H. Pilkey, Sr. and R. Turner, How to Live with an Island. North Carolina Department of Natural and Economic Resources, Raleigh, North Carolina, 1975.

Platt, Rutherford H., "The National Flood Insurance Program: Some Midstream Perspectives." Journal of the American Institute of Planners, (July 1976), pp. 303-314.

Poland, J. F., :Land Subsidence in Western United States," in R. A. Olson and M. W. Wallace, Eds. Geologic Hazards and Public Problems, pp. 77-96. Washington, D.C.: U.S. Government Printing Office, 1969.

Poland, J. F., and G. H. Davis, "Land Subsidence Due to Withdrawal of Fluids." Reviews of Engineering Geology, Vol. 2, 1969, pp. 187-269.

Radbruch-Hall, D. H., et al., "Preliminary Landslide Overview Map of the Conterminous United States." U.S. Geological Survey, MF-771, 1976.

Rosenthal, S. L. and M. S. Moss, Numerical Experiments of Relevance to Project Stormfury. NOAA Technical Memorandum #ERLNHRL095. Washington: U.S. Department of Commerce, 1971.

San Francisco Department of City Planning, Community Safety Plan for the Comprehensive Plan of San Francisco. San Francisco, 1974.

Simpson, R. H. and M. B. Lawrence, Atlantic Hurricane Frequencies Along the U.S. Coastline. NOAA Technical Memorandum #NWS SR-58. Washington, D.C.: U.S. Department of Commerce, 1971.

Slosson, J., "The Role of Engineering Geology in Urban Planning." The Governor's Conference on Environmental Geology, April 30-May 2, 1969. Sacramento: State of California, pp. 8-14.

Sorensen, John, et al., Landslide Hazard in the United States: A Research Assessment. Program of Research on Technology, Environment and Man. Boulder: Institute of Behavioral Science, University of Colorado, 1975.

Sorensen, John H., with J. Kenneth Mitchell, Coastal Erosion Hazard in the United States: A Research Assessment. Program of Research on Technology, Environment and Man. Boulder: Institute of Behavioral Science, University of Colorado, 1975.

Staff, Assessment of Research on Natural Hazards, Snow Avalanch Hazard in the United States: A Research Assessment. Boulder: Institute of Behavioral Science, University of Colorado, 1975.

Sugg, Arnold L., "Economic Aspects of Hurricanes, "Monthly Weather Review 95, 1967, pp. 143-146.

Tazieff, Haroun, "The Menance of Extinct Volcanoes," Impact 17, No. 2, 1967 pp. 135-48.

Texas General Land Office, Texas Coastal Management Program. (Hearing Draft) June, 1976.

U.S. Army Corps of Engineers, Dune Formation and Stabilization by Vegetation Plantings. Technical Memorandum #101. Washington, D.C. U.S. Government Printing Office, 1957.

______________, Creation and Stabilization of Coastal Barrier Dunes. Report #3-69. Washington, D.C.: Coastal Engineering Research Center, 1969.

______________, Experimental Dunes of the Texas Coast. Miscellaneous Paper #1-70. Washington, D.C.: Coastal Engineering Research Center, 1969.

______________, Report on the National Shoreline Study. Washington, D.C.: U.S. Government Printing Office, 1971.

______________, Shore Management Guidelines: National Shoreline Study. Washington, D.C.: U.S. Government Printing Office, 1971a.

______________, Shore Protection Guidelines. Washington, D.C.: U.S. Government Printing Office, 1971b.

______________, The Cook Inlet Environment. Anchorage: Alaska District, August 1972.

______________, Flood-Proofing Regulations. U.S. Department of the Army. Washington, D.C.: U.S. Government Printing Office, 1972a.

______________, Great Lakes Shoreline Damage: Causes and Protective Measures. Chicago: North Central Division, 1972b.

______________, Ecological Effects of Offshore Dredging and Beach Nourishment: A Review. Miscellaneous Paper #1-73, Washington, D.C.: Coastal Engineering Research Center, 1973.

______________, Help Yourself: A Discussion of the Critical Erosion Problems on the Great Lakes and Alternative Methods of Shore Protection. Chicago: North Central Division, 1973a.

U.S. Bureau of the Census, U.S. Census of Population: 1960, Number of Inhabitants. U.S. Department of Commerce, Washington, D.C.: U.S. Government Printing Office, 1961.

____________, U.S. Census of Population: 1970. U.S. Department of Commerce, Washington, D.C.: U.S. Government Printing Office, 1971.

U.S. Department of Commerce, A Plan for Improving the National River and Flood Forecasting and Warning Service. Cited in Office of Emergency Preparedness, 1972. Disaster Preparedness, Vol. 1, p. 25. Washington, D.C.: U.S. Government Printing Office, 1969.

U.S. Department of the Interior, National Park Service. Statement for Management and Environmental Assessment - Gateway National Recreation Area, New York/New Jersey, April 1976.

U.S. Water Resources Council, Regulation of Flood Hazard Areas to Reduce Flood Losses. Volume 2, Parts v-vi, Washington, D.C.: U.S. Government Printing Office, 1972.

Von Heune, Roland and Doak C. Cox, "Locally Generated Tsunamis and Other Local Waves." The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering. Washington, D.C.: National Academy of Sciences, 1972, pp. 211-221.

Waldron, Howard H., Debris Flow and Erosion Control Problems Caused by Ash Eruptions of Irazu Volcano, Costa Rica, U.S. Geological Survey Bulletin #1241-1, Washington, D.C.: U.S. Government Printing Office, 1967.

Wallace, Robert E., Goals, Strategy, and Tasks of the Earthquake Hazard Reduction Program, Geological Survey Circular 701, USGS, Dept. of the Interior, Washington, D.C., 1974.

Warrick, Richard A., Volcano Hazard in the United States: A Research Assessment. Boulder: Institute of Behavioral Science, University of Colorado, 1975.

White, A. U., "Global Summary of Human Response to Natural Hazards: Tropical Cyclones," in G. F. White, ed., Natural Hazards: Local, National, Global. New York: Oxford University Press, 1974.

White, Gilbert F. and J. Eugene Haas, Assessment of Research on Natural Hazards. Cambridge: MIT Press, 1975.

Whitman, R. V., Seismic Design Decision Analysis: Summary of Methodology and Pilot Applications. Structures Publication #381. Cambridge, Massachusetts: MIT School of Engineering, 1973.

Wiggins, J.H. and D. Moran, Earthquake Safety in the City of Long Beach, Based on the Concept of "Balanced Risk." Report prepared for the City of Long Beach, Redondo Beach, California: J.H. Wiggins Co., 1971.

Wilcox, R.E., Some Effects of Recent Volcanic Ash Falls, with Especial Reference to Alaska. U.S. Geological Survey Bulletin 1028-N. Washington, D.C.: U.S. Government Printing Office, 1959. Cited in Coastal Processes, Terrain, and Hazards, Alaska Department of Environmental Conservation, Environmental Analysis Section, Juneau, 1976.

Wilkinson, K.P. and P.J. Ross, Citizens's Responses to Warnings of Hurricane Camille. Social Science Research Center Report #35. State College: Mississippi State University, 1970.

Wood, Fergus J., The Strategic Role of Perigean Spring Tides in Nautical History and North American Flooding, 1635-1975. Washington, D.C.: NOAA, 1976.

SECTION III

PROBLEMS AND RECOMMENDATIONS

III. PROBLEMS AND RECOMMENDATIONS

A comprehensive coastal zone management program should address the problems created by extreme natural events because these hazards potentially threaten life, property, and the natural environment. The coastal managers should have some knowledge of what kind, what magnitude, and what frequency of hazard can occur throughout the coastal areas as they structure a program. Having recognized the problem, coastal managers are then in a position to propose effective means for adapting to such hazards, including information programs for the general public about hazard characteristics.

In some states, substantial efforts have already been exerted to deal with the problems associated with natural hazards, either independent of or in concert with one or more Federal agencies. These efforts should be carefully examined by the coastal manager for their adequacy and for their relationship with the overall CZM program. In other states, weak or inadequate efforts demand significant upgrading or restructuring to reflect current technical knowledge, to enhance popular awareness, and to incorporate a hazard management component.

The importance of planning to manage potential coastal hazards is specifically recognized in the regulations which the Office of Coastal Zone Management has promulgated to assist states in developing and gaining Federal approval for their CZM programs (15 CFR 920 and 923). When speaking of those elements which a comprehensive program should consider, the regulations specifically mention "floods and flood damage prevention, erosion (including the effect of tides and currents upon beaches and other shoreline areas), land stability, climatology and meteorology" (923.4).

The regulations most directly address the delineation of hazard areas in the section concerning areas of particular concern (923.13). According to the regulations, "such designation shall be based upon a review of natural and man-made coastal zone resources and uses, and upon consideration of State-established criteria which include... (among others) ...areas of significant hazard if developed, due to storms, slides, floods, erosion, settlement, etc." They go on to say "particular attention in reviewing the management program will be directed toward development by the state of implementing policies or actions to manage the designated areas of particular concern."

By implication, the hazard potential in coastal areas should also be examined by coastal states when delineating permissible land and water uses (923.12), where states are required, among other things, to develop a procedure which includes "an analysis or establishment of a method of analysis of the capability and suitability for each type of resource and application to existing, projected or potential uses." States are required to develop guidelines on the "relative priorities which will be accorded in particular areas to at least those permissible land and water uses identified" above, including specifically those uses of lowest priority (923.14).

To the extent that hazard management and control is a part of a comprehensive coastal program, state CZM agencies are also required to include the cognizant state agency within their organizational structure (923.22), may elect to take advantage of that agency's authorities to administer land and water uses and control development (923.24), should provide for full participation of affected agencies and persons in the adoption of the management program (923.31), and demonstrate that the program has been coordinated with other relevant planning (923.32).

The requirements cited above are, of course, ones with which coastal managers are presumed to have dealt in the course of their program development to date. Of equal pertinence at the present time are those new requirements to which coastal managers must respond as a result of the passage of the Coastal Zone Management Act Amendments of 1976. Principal among these are the three new planning requirements which have been added to the program development phase (Section 305). These requirements, for which regulations have not as yet been promulgated (November 1976), call upon states to develop planning processes for: 1) protection of and access to public beaches and other public areas; 2) energy facilities likely to be located in or impact upon the coastal zone; and 3) assessing the effects of shoreline erosion and evaluating ways to control that erosion.

In meeting these new planning requirements, state CZM agencies may need to re-examine technical work done to date and reassess current state policies. The erosion planning requirement is obviously the one that is most directly related to the issue of natural hazards. However, states will undoubtedly want to examine the hazard potential of sections of the coast, and perhaps specific sites as well, when they deal with the impacts of energy facility siting. Finally, states may well incorporate hazard management into their planning for the protection of public beaches and other public coastal areas of environmental, recreational, historical, esthetic, ecological, or cultural value.

Hazard potential will be of particular interest to those states and communities which participate in the Coastal Energy Impact Program established by the 1976 Amendments. This program is intended to assist those states and communities which incur major onshore impacts from the development of outer continental shelf oil and gas. Impacted areas are eligible for loans and guarantees to finance public facilities and services required because of this development. The location of these facilities and the kinds of services provided will certainly be affected by the full range of natural hazards. Four major types of problems are common to the majority of state agencies dealing with natural hazards in their coastal areas. Each of these presents several specific issues which are reviewed along with recommended lines of response in the following pages.

Wherever practicable, the discussion of problems is related to the procedures which the state CZM agency may follow in meeting the requirements for program approval and for designating areas of particular concern, defining permissible uses, establishing priority uses, and estimating the effects of public facilities and services for energy production. None of these tasks can be accomplished satisfactorily without some assessment, however informal, of likely consequences. The way in which this will be done will be shaped by prevailing state policy and procedures. Although the details of state organization and authority vary greatly (as indicated in the detailed tabulations in Section IV), the institutional problems are similar throughout the states.

The four types of problems relating to natural hazards in management of coastal land and water are: (a) delineating hazard areas; (b) defining the options in coping with the hazard, (c) improving citizen awareness and participation, and (d) organizing and coordinating the government agencies involved. Each of these presents specific issues on which recommendations (italics) are made.

A. Delineating Hazard Areas

In the management of any area vulnerable to natural hazards, an essential first step is delineation of the localities most likely to be affected. Without this step, the possibility of any effective management action is severely reduced. In many instances, a precise delineation is not possible, but it is important that some designation be made, no matter how imprecise. These rough estimates can then be revised as new or more complete information becomes available.

Many state CZM programs have approached the problem of mitigating hazards by identifying hazard areas as Geographical Areas of Particular Concern (GAPCs). This designation also includes land required to meet environmental conservation and economic development needs. Where different types of GAPCs are geographically distinct and mutually exclusive there is a danger that measures to mitigate spatially widespread hazards will be frustrated. It is desirable that hazard zones which are designated as GAPCs should be as broad and inclusive as possible.

Major problems involved in delineation of hazardous zones are: the scale and detail of hazard area mapping; the use of conflicting information from various sources; definition of hazardous conditions with special reference to seismic risk; and making understandable the recurrence probability of the extreme events.

1) Scale and detail of mapping

A preliminary step in delineating hazard areas is to make some designation of the area at whatever scale and detail are permitted by the available evidence. It is sometimes argued that unless a very accurate map of a hazard zone can be provided, it is better to offer no designation at all. To take this position would mean that many hazardous parts of the coast would remain unidentified for a long time. It is always possible to make a rough designation of a hazard area and to state explicitly that this is subject to revision as more information becomes available.

Thus, the vulnerability of a sector of the coast to hurricane hazard may be stated in the very rough terms shown in Figure II-3, indicating the approximate recurrence intervals of storms of hurricane strength. At the other extreme are the maps prepared by the Federal Insurance Administration which show the estimated location of lands subject to floods of probabilities of one per cent (1%) or more. Between these extremes of accuracy are a large number of possible combinations of scale and detail that result from the character of the scientific information available.

It is desirable to attempt some kind of designation of hazard areas along each sector of the coast, using whatever scale and detail of map is appropriate and coincides with the available information. This can always be done, provided there is explicit recognition that the precision of the map shall be revised as more information becomes available.

2) Inadequate and conflicting data sources

Public officials dealing with coastal management seldom encounter generally accepted information on natural hazards. More often they are confronted with estimates of hazard vulnerability which are in apparent conflict. For example, estimates of storm surge from a hurricane of given magnitude may differ from the U.S. Geological Survey, the Corps of Engineers and a consultant employed by the Federal Insurance Administration. These differences result from differing sources of data and modes of analysis. It is impossible to reconcile data or methods by conference or exchange of memoranda, unless the state has access to a scientific agency which will synthesize and assess the several estimates, as was the case in the preparation of a map of shoreline vulnerability prepared for the Texas coast (Brown, et al., 1974). It is usually necessary to find out precisely what differences have occurred in data base or in method and then to determine what is the most suitable combination of data and method for a particular locality. The American Arbitration Association has an experimental project on data validation for the New Jersey coast which may be more generally applicable. Where there remain unreconciled differences, it is important to present the whole array of estimates so that the public may be aware of them.

This problem occurs in determining areas subject to flooding by overbank flow along coastal streams. Most of the conflicts in judgments are among professional workers in organizations using differing specified procedures and standards. Such conflict in estimates need not seriously impede the publication of a delineation of a vulnerable zone.

Local interests sometimes argue that unless the delineation of a hazard area is precise and of unquestioned scientific validity, it cannot be used for purposes of establishing areas of particular concern or to designate permissible land uses, subdivision regulations, special building codes, and the like. This, in practice, has not been a crippling consideration. However, this view can trigger severe political obstacles which may hamper the adoption of land management measures in hazardous areas.

The general position of the courts has been that a hazard area may be delineated with full knowledge that data are rough; so long as the evidence is stated, and competent scientific judgment is brought to bear on analysis of the data (e.g. Just v. Marinette County 201 N.W2d 761, 1972; Sibson v. State 336 A.2d 239, 1975). The resulting determination can be accepted with the understanding that it shall be revised as new information is obtained or as more sophisticated methods of analysis are developed. Likewise, a delineation may be changed repeatedly as a result of public hearings or protest by individual property owners in accordance with explicit provision for revision and variance.

> *It is recommended that any designation of a hazard area be accompanied by explicit statements that: a) reasonable use has been made of available scientific information, indicating the sources of such information, and b) there will be opportunity for public examination and review of the designations with subsequent revision of them insofar as new information or scientific interpretation warrants revision of the boundaries.*

A nagging question which accompanies any estimate of vulnerability to water movement along the coast is that of the prospect that the ocean level in the future will rise or fall at an accelerated rate. It is possible that such changes are underway but not yet identified. When local groups assert that the delineation of hazard zones will be altered by changes in ocean level resulting from shifts in global atmospheric patterns, a reasonable response is that it is not impossible but that the evidence does not yet warrant any change in delineations. It may be helpful to conduct sensitivity analyses of alternative adjustment plans in order to determine which options will stand up best to future climatic or other changes, should they occur.

3) Defining hazardous conditions

Determining whether hazardous conditions exist is subject to many scientific difficulties, often requiring the analysis of conflicting information. An illustrative example is the attempt to define an area subject to seismic risks. Here it is possible to state the probabilities of occurrence of an earthquake of a given magnitude in an area where there is an earthquake disturbance record of 100 years or more. However, this does not help in dealing with areas where a major event has few recorded precursors and relatively few events thereafter, e.g. the great Charleston earthquake of 1886 or the Boston earthquake of 1755. Nor does it assist in differentiating the relative vulnerability to damage of pieces of land within a very small area according to their susceptibility to ground motion from an earthquake. As indicated in the mapping of vulnerability to liquefaction in the San Francisco Bay area (Figure II-15), it is possible for an area to be highly subject to liquefaction and consequently severe motion, whereas a neighboring area only a short distance away may be relatively secure.

In these circumstances it is important to obtain the best available judgment of seismologists and earthquake engineers of the relative vulnerability of an individual building or property. It is also important to recognize that there are grounds for honest differences of judgment of the degree of risk and of the appropriate design of earthquake resistant structures.

In California, coastal zone planning for adjustment to seismic hazards is based almost entirely on liquefaction potential, as determined by soil analyses, while the state-wide seismic hazards adjustment program is based largely upon proximity to active fault zones. The two may require reconciliation.

> *Wherever special questions exist about the basis for designating the degree of hazard in an area, such as one of seismic risk or of the extent of tsunami run-up, it is desirable to commission a special report by a state or Federal agency or by a consulting firm. Requests for such reports should include a specification of the type of extreme event which is to be examined, the types of land use for which the area is to be considered, and the degree of risk which it is believed the community is willing to accept.*

4) Making probabilities understandable

Many estimates of the vulnerability of an area to an extreme event, such as flooding, hurricane surge or seismic movement, include an estimate of probability of recurrence. Without some judgment of probability, however rough, it is only possible to say that an area may be subject to the extreme event without indicating the degree of likelihood that such an event will occur. Such designation may be of little value in land and water management unless accompanied by an indication of frequency. The most common method of estimating probability is to analyze the data from past events or from the occurrence of those events in similar areas, such as neighboring drainage basins or earthquake zones. This always involves statistics that are at best subject to inaccuracies in the original measurements and which seldom are available for a period of more than 50 to 100 years.

It is desirable, nevertheless, when considering power plant siting or the wisdom of dense residential development, to estimate the likelihood of recurrence of rare events. A device used in the Federal Insurance Administration reports for describing the recurrence interval is delineation of a "100-year flood." This wording suggests to some people that a flood is expected to occur once in 100 years and in that case is misleading. It would be more accurate to state that a flood of defined magnitude had a one per cent (1%) chance of occurrence. In each year there is a one per cent chance that it will occur. There could be two or more occurrences of an event of that magnitude in a given year. It is important to explain that the probability is the same every year regardless of the time of the previous occurrence of an event of that magnitude.

On the other hand, the concept of annual probabilities may fail to convey the true nature of a threat over time. In deciding for which magnitude of event to plan, the probability of certain events occurring at least once during some time span longer than a year should be taken into account. Thus, many business transactions are for 10-year periods, few mortgages exceed 25 years, and the length of one person's wage earning rarely exceeds 50 years. Probabilities for these periods are as follows:

Event (Annual Probability)	Probability of Occurring at Least Once in*		
	10 yrs	25 yrs	50 yrs
10-year (.10)	.65	.93	.99
25-year (.04)	.34	.64	.87
50-year (.02)	.18	.40	.64
100-year (.01)	.10	.22	.39

*A probability of 1.00 = certainty that an event will occur in a stated period.

Even though it is not practicable to show with accuracy the detailed recurrence interval of an extreme event such as a flood or hurricane in a small river valley or a sector of the coast, it may be practicable to indicate the approximate recurrence intervals of this type of event drawn from examination of regional data. Examples are the estimates of hurricane recurrence shown in Figure II-3 and of flood occurrence for regions in the Tennessee Valley prepared by the Tennessee Valley Authority. These can be shown both as annual probabilities, and as probability of occurrence over a stated time period.

Wherever possible, a recurrence interval should be designated as a percentage of occurrence rather than a number of years. This avoids confusion about the timing of an event and recognizes that the extreme events tend to occur on a random rather than a periodic or cyclic basis.

When presenting the results of any analysis of probabilities of extreme events, it is important to state that larger and less frequent events than those of a designated probability may conceivably occur. In areas subject to flood or hurricane storm surge designated as being within the "100-year" (one per cent, 1%) zone, public agencies and citizens should be informed that larger and less frequent events may occur and that these may bring far greater social dislocation and loss than the more frequent events for which plans are made.

B. Defining and Evaluating the Options

The principal problems associated with defining and evaluating hazard adjustments in coastal areas are: describing the range of possible adjustments; the issue of private property rights; predicting the interactions among various alternative adjustments; and assisting the local and state groups in understanding the choices open to them.

1) Range of adjustments

One of the primary difficulties encountered in appraising natural hazards in coastal areas is identifying the full range of possible adjustments to an extreme event. Conventional approaches associated with agency missions tend to dominate public and technical consulting thought. Moreover, it is hard for individuals or groups to canvass more than a couple of alternatives at one time. In practice, individuals and communities tend to settle on a combination of adjustments when given an opportunity. In contrast, when a public body is faced with making a choice it tends to adopt one adjustment to the exclusion of others.

The role of coastal managers is to make certain that all parties concerned are aware of the full range of choices and of the costs and benefits attaching to each.

Reports from engineering consultants on beach erosion control works increasingly emphasize the alternative of beach management as a means of reducing erosion, but may not be strong on methods of general land use management or of dune stabilization by vegetation practices. Similarly, the opportunity to provide information to citizen or business groups to influence decisions to locate in hazardous areas often is neglected when reliance is placed on formal measures such as building codes or subdivision regulations.

Agencies dealing with extreme events tend to be wedded to one type of action. There is a disposition to find some means of controlling the event by engineering or other physical measures. The classic cases are breakwaters to retard coastal erosion, and dams and restraining works to contain or hold back flood flows. Similarly, in the field of land use management there is a tendency to concentrate on more traditional zoning regulations without considering a variety of other devices that are conceivably available. This would include in the case of hurricane hazard the opportunities for reducing risk by changes in the location and design of buildings, by improvements in evacuation plans, and by education of the population at risk to the options that are open to them. In some inland flood situations it has proved more effective for a community to purchase the land at risk than to engage in protection measures, as illustrated in the Littleton, Colorado flood plain.

A major task for the agency concerned with management of coastal land and water is to prepare an array of all theoretically possible measures, whether or not they are customarily employed by established agencies.

It should always be practicable to include in the form of a list, table, or diagram the types of adjustments which are possible in a given area and those which, in fact, are adopted at the time of the study. This will often help to dispel public beliefs that there is only one course of action which can be considered in dealing with a hazard or that the types of actions which have been taken in the past are the only ones which can be taken in the future.

One way of presenting these is in the form of a table as shown in Appendix E.

2) Private property rights

A common question raised about land use management plans for vulnerable areas is whether or not the zoning, subdivision, or building regulations deprive property owners of use of their property for profitable purposes. Although it may be a profound concern among property groups in the community, this need not be a major legal issue, so so long as whatever regulations are enacted and enforced leave one or more productive use options open to the property owners. These uses may include such purposes as golf courses, public parks, parking lots, and other open space or low density activities for which property may be sold and which may yield a return. Those uses may be far less remunerative than high density residential or commercial uses, but at this point it becomes important to recognize the cost to the community of permitting the higher yield uses. These costs include:

The cost of emergency warning services;
Emergency evacuation relief to disaster victims;
Rehabilitation to damaged properties and families;
Repair of public utilities injured by the extreme event;
Contributions to the construction of protective works required by the citizenry once a vulnerable area has been occupied and damaged.

All of these raise the long-term public cost of the occupied area and need to be estimated in order to compare them to the gains which would accrue to private property owners if they were allowed to exploit the vulnerable area for higher uses. A California Superior Court decision (Sheffert vs. Los Angeles County, Case No. 32487) held the county responsible for private property damage resulting from development in a hazardous area for which the county had issued a permit. If the courts generally adopt this opinion, the public agencies will be forced to regulate development even more carefully.

One effective means by which communities can guide the occupation of vulernable areas is in their regulation of public utilities construction in such areas. Communities faced with sudden major potential growth (e.g. in response to OCS development) may find this approach particularly useful. By designating which lands will or will not be served by public water supply, sewer services and paved streets, they may influence the use of the land without zoning ordinances and building permits. In the lake plain of the Chicago metropolitan area, for example, the rule of the Metropolitan Sanitary District in determining what areas would be serviced by trunk sewers was effective in bringing about the land use planning and regulation in flood vulnerable areas of the member communities.

It may be desirable to show how regulation of the use of a sand dune area would reduce the subsequent expenditures for dune stabilization and for beach protection in the event that a degradation in the dune vegetation were to be permitted.

A recent study in two northwest Florida communities indicated that there may be more public support for hazard zone regulations than had previously been believed. Between 70-85% of the residents favored coastal setback legislation, flood plain zoning, hurricane wind building codes, and mobile home tie down requirements. Wind-related building codes were least popular. Infringement on property rights was seldom mentioned as a reason for opposing the laws. The original survey was taken shortly after a hurricane in the area, but a year later there had been no diminution of support (Baker, 1976a).

> *Wherever there is discussion of the desirability of public regulation of private land use as a means of coping with the hazard of extreme events, a specific statement, possibly in the form of a scenario, should be made of the probable public effects of permitting continued development of that area. This should include a listing of the costs that would accrue to public agencies in providing for emergency warning, evacuation, disaster relief, rehabilitation services, the repair of public utilities, and likely local participation in the cost of eventual protective works for the developed property. It also should include an estimate of the degree to which the life of the community may be dislocated by the occurrence of the extreme event, and the likely costs to private citizens.*

3) Interactions among adjustments

Whatever the number of adjustments that seem to merit consideration in a particular coastal location, it is important to remember that the array of possibilities is dynamic rather than static. The suitable mix of adjustments for a given shoreline can change as a result of two sets of factors that are at work.

First, circumstances on the national scene may influence the costs of and benefits from the adjustment. These circumstances include:

Changes in composition and density of coastal populations (e.g., crowding toward beach locations, seasonal increases in numbers of residents);
Changes in technology (e.g., capacity to exploit offshore oil resources);
Changes in public tolerance of risk (e.g., unwillingness to accept the hazard of loss of life from occupying a house on a site permitted by a municipal agency).

For example, OCS energy production facilities are generally designed to operate during a wide range of extreme physical conditions, thus making oil and gas available to onshore support and processing plants even during periods of severe onshore hazard. This tends to encourage the "hardening" of processing industries to withstand extreme conditions and prolongs their operation during hazard events. For these and other reasons the judgment of what is an appropriate choice may change. A careful appraisal of the alternatives will help identify some of the changes that are in progress. This would include, for example, an estimate of the degree to which the vulnerability of an area to damage would be affected by the continued trend in use of mobile homes as either year-round or seasonal residences.

Each statement of the plans for management of a coastal hazard area should include an estimate of the extent to which the occupation of the area is likely to be affected by changes in population, technology, or risk tolerance.

Second, the adoption of one adjustment may encourage or hinder the adoption of others. For example, where subsidized insurance is provided to occupants of homes within the reach of storm surge there may be less interest in flood proofing the structure. However, the regular insurance program, in contrast to the emergency program, requires enactment of land use regulations governing further invasion of the one per cent (1%) probability zone. It has been suggested that the availability of flood insurance has encouraged banks in Rhode Island to offer mortgages for second homes on oceanfront sites. In turn, this facilitates further increases in the amount of investment exposed to risk from inundation, coastal erosion and wind damage.

The Texas Catastrophe Property Insurance Association, established in 1971 by the Texas legislature, requires insurance companies to pool their resources and provide coverage of high wind risk areas. The insurance premiums will hopefully be integrated with building codes, encouraging adoption of minimum hurricane building standards. The interrelationships of adjustments for floods illustrated in Figure III-1 reveals that some of the linkages are known and others are still speculative. It should be recognized that in some cases the provision of insurance against hazard damage may deter property owner interest in the adoption of more rigid standards for the design of hazard resistant structures. Organization of improved flood warnings may stimulate interest in flood proofing. A similar rough matrix can be constructed for any coastal location where there are choices among adjustments.

In describing the range of possible adjustments to a natural hazard it is important to state the extent to which one adjustment may be expected to affect adoption of other adjustments.

4) Assisting in the choice

When choosing a mix of hazard adjustments, the results can be no better than the information upon which the choice is based. One of the types of information required is an impact estimate. Essentially this is the projection of what consequences will follow if a certain mix of adjustments is chosen and a certain combination of extreme events occurs.

Subject to certain additional constraints, the objective of any natural hazard adjustment program is essentially to minimize three broad areas of adverse effects resulting from hazard occurrence. This objective

Initial Adjustment	Other Adjustment Affected: Control and Protection	Flood-Proofing	Land Use Planning	Warnings	Insurance	Relief and Rehabilitation
Control and Protection		○	○	○	○	○
Flood-Proofing	○		○	●	?	○
Land Use Planning	○	?		●	●	○
Warnings	○	●	●		?	○
Insurance	○	?	?	●		○
Relief and Rehabilitation	●	○	○	○	○	

Affected by the initial adjustment:

● - High affect

○ - Little or no affect

? - Doubtful

FIGURE III-1

INTERACTIONS AMONG FLOOD ADJUSTMENTS

might be termed loss aversion. The first of these categories is the threat to human health and safety. It is important to know the effects of potential hazards in terms of loss of life, extent of injuries, and possibly, occurrence of disease. It should be possible to estimate the degree to which each of these effects will be changed by the adoption of each particular adjustment alternative or by mixes of adjustments.

Second, natural events cause property damages, to non-commercial and private property, to commercial private property, to commercial and industrial property, and to public property. It is important to be able to estimate such damages, and the extent to which they might be reduced by the adoption of each particular adjustment alternative.

Third, natural events cause social surprise and disruption. Estimating such effects is difficult. Indirect economic costs, such as those due to disruption of communication and transportation networks, are clear in principle but somewhat difficult to estimate in practice. Some of the non-economic aspects of surprise and disruption (e.g., changes in attitudes and beliefs, and changes in the functioning of social institutions) are neither clear in principle nor easy to estimate.

A statement of the choices which are available should include an estimate of the extent and type of loss aversion, in terms of human health and safety, property damages, and social surprise and disruption.

Loss aversion, although the primary objective of hazard adjustment programs, is not the only factor which should be considered. The cost (not necessarily monetary) of the alternative under consideration is also important, as are other impacts, or side effects, which may be positive or negative. Chief among these in coastal zone planning is impact on environmental quality. Hazard adjustments may improve or degrade the natural environment. In the hurricane zone, for example, intensive use of the area can aggravate coastal erosion, destroy dunes and beaches, and degrade ecologically sensitive areas such as mangroves. McHarg (1969) argues that natural processes often work to man's advantage, and that the less those processes are disrupted the greater will be their benefits to society. Bulldozing of dunes interferes with the protection against storm surge afforded by these natural features.

Other kinds of impacts can also be important. These can occur when natural hazard adjustments also involve potential effects on scenic, historic, cultural, and recreational areas, and upon economic development. Such effects should be considered and appraised.

A statement of available choices should also include some indication of whether a given choice may protect or may lead to degradation of other environmental features. Even though monetary estimates cannot be made of the environmental consequences, some indication can be given of their likely magnitude. Similar estimates of impacts on other coastal resources and activities should be prepared where relevant.

Identifying and projecting the magnitude of impacts of alternative hazard adjustments is subject to the same problems of inadequate and conflicting information discussed previously. It is further complicated by the human tendency to assume that the future will follow the pattern of the past. When dealing with natural hazards, in particular, this reliance on extrapolation can lead to poor decisions.

Natural hazards differ from other aspects of coastal zone planning in one important respect; the more disastrous the event the less likely it is to occur. This is fortunate, of course, but it complicates planning because most people find it difficult to act on the basis of potential events which are outside of their experience. The tendency is well illustrated by the almost total lack of consideration of earthquake hazards in the eastern United States and a similar discounting of the tsunami and hurricane hazards in the West. Such events are rare in these regions, but they will occur and when they do the potential for destruction is great.

Impact assessment should recognize and deal with the improbable but catastrophic event. Most planning reports express impact estimates as if only one outcome were possible. In other words, the tendency is to limit attention to the most likely outcome and ignore other possibilities which may carry very different consequences. This practice can lead to poor choices in general, and to almost complete neglect of natural hazard adjustments in particular. To avoid this mistake, planners should seek ways of presenting and analyzing a range of possible outcomes, and of estimating the probability of occurrence of each. One or more illustrative possibilities may be described, and their probabilities of occurrence may be estimated (see p. III-7). Scenarios which portray consequences of extreme events are one way of doing this, although they should not then be used arbitrarily as the basis for planning, as is the 100 year flood for example.

There is a growing literature of scenarios which present graphically the likely effects of an extreme event. These help in choosing one form of adjustment over another. Estimates of the consequences of an earthquake in San Francisco have been presented by several study groups (White and Haas, 1975; Rinehart, Algermissen and Gibbons, 1976). It may be possible to encourage local universities or government agencies to make this kind of an estimate to demonstrate the magnitude and extent of a hazard. The methodology is outlined in the report by Erickson (1975). An example of this is given in the scenario for hurricanes in Miami, Florida, in Appendix D.

> *One useful way of projecting the likely consequences of choosing one adjustment over another is to prepare scenarios of the estimated effects of the occurrence of an extreme event under stated assumptions of the type of land use and the character of public activities prevailing at the time the event occurs.*
>
> *An adequate set of impact estimates will: 1) describe the potential consequences of each adjustment alternative (including taking no action), 2) describe impacts in terms of those outcomes which are most important, and 3) reveal the probabilistic*

nature of potential outcomes. The next step is to evaluate the various adjustment alternatives, and compare their estimated impacts.

Comparing alternatives and choosing between them is a process infused with value judgments. It is a political, as well as a technical task. Technical imput is necessary, in a form which will facilitate an enlightened political choice. In this respect, there are several methods for presenting impact estimates which may make them more meaningful and useful to those who must choose. Such methods as benefit-cost, cost-effectiveness, and balanced impact analyses are well known. (See Howe, 1971 for a description of the methodology.) All are designed to facilitate comparison between alternatives.

Benefit-cost analysis originated in part in the evaluation of such Federal natural hazard adjustments as flood control, coastal erosion control and hurricane protection. It solves the problem of incomparability of impact estimates (non-commensurability, in technical terms) by assigning market-determined monetary valuation to dissimilar impacts. For the many impacts which are not market-valued, some technique must be used to construct monetary values or other bases for comparison. Benefit-cost analysis substitutes market valuation for political valuation, and for this reason may be inappropriate. Finally, benefit-cost analysis works best for capital investment projects, and tends to be less useful where investment is not a major aspect, as in land use regulation.

Cost-effectiveness analysis is easier to perform, but is more limited in its value premises, and more limited in application as well. It consists of a comparison of the monetary costs of accomplishing a given objective by alternative means. Non-monetary costs are not considered and neither are the many impacts (side effects) produced in addition to attainment of the single objective. Like benefit-cost analysis, it is difficult to use in comparing such adjustments as land use controls, whose direct costs are minor considerations.

Balanced impact analysis attempts to make an event which is outside of normal experience easier to visualize and appreciate by constructing an analogy with a more common event with similar consequences. For example, the risks from a hurricane landfall may be compared with those of driving an automobile. One major problem with such an alysis is that it requires a consistent data base, which generally is not available.

Each of these analytical devices, however limited and imperfect, should be used, where appropriate, in coastal zone planning to encourage and facilitate the comparison of alternatives. Their purpose is to make impact estimates more useful in that context. What is important is not the particular form of analysis employed, but the existence of a critical and comparative perspective on the part of both technical planners and decision makers.

Any discussion of natural hazards adjustment options should include an outline of the major trade-offs which the community will experience in choosing one option over another.

Much of the traditional benefit-cost analysis deals with aggregates for the nation, a region, or a locality. It does not separate out the effects as they fall upon specified groups in the nation or community. The continuum of effects may extend from death to increased taxation (see Figure III-2). In recent years distributional effects have commanded greater public attention, and efforts have been made to show who gains from, and who pays for a given investment or regulatory program (Cochrane, 1975). The differences in effect of three types of extreme events are shown in Figure III-3. This does not reflect the distribution of total costs, including cost of public improvements. Depending upon public fiscal policy, there is no direct correlation between the benefits received and the costs paid.

A statement of the choices which are available should include an estimate of the likely distribution of the major costs and benefits among different sectors of the community and among the Federal, state and local beneficiaries.

Planning for natural hazard adjustment in the coastal zone is undertaken within a climate of uncertainty, as discussed in previous sections. To date, a common but unfortunate way of dealing with this uncertainty has been to ignore it. Although recognition of uncertainty is necessary, it is not sufficient. Something must be done about it as well.

One basic decision-making strategy is to preserve as much flexibility as possible, so that if better information becomes available, or conditions change in the future, desirable courses of action have not been foreclosed. The adoption of such a strategy would place greater emphasis upon identifying and avoiding irreversible choices when evaluating alternative adjustments. For example, some adjustments might produce ecological changes which could not be reversed. Others may produce social changes which would be practically irreversible.

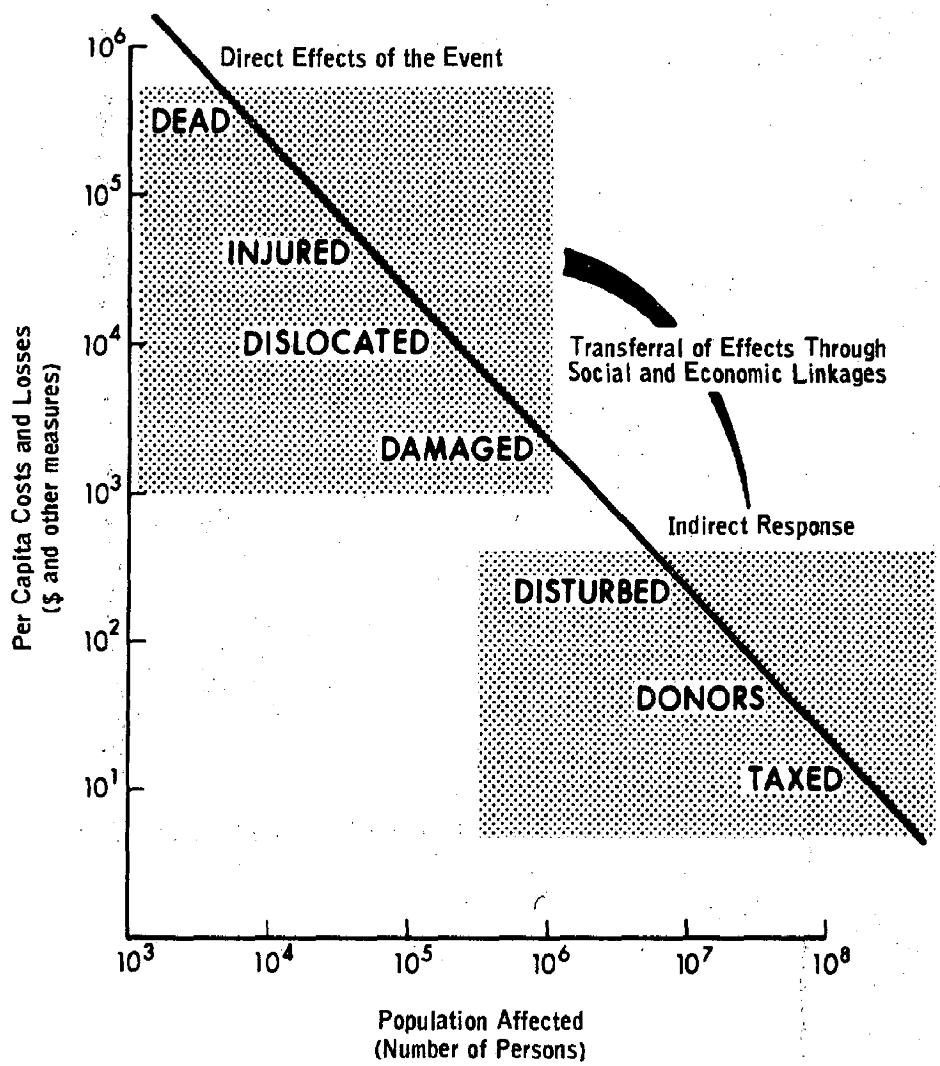
A policy to consider in presenting the choices open to communities along the coast is to identify the options which maintain maximum flexibility so as to avoid taking action which would lead to irreversible changes with adverse social or environmental consequences.

C. Improving Citizen Participation

Public participation is expected throughout the process of delineating, determining permissible use of and planning suitable management for vulnerable areas. The extent and nature of the participation is affected by the format in which information about hazards and the recurrence of extreme events is made available, the networks of citizen groups through which the information is disseminated, and the role which is assigned to citizen organizations in reviewing the scientific information and the administrative options. A troublesome aspect of these efforts is the ability to distinguish arousing awareness of a natural hazard from providing a sense of efficacy to deal with the extreme event before or when it occurs.

FIGURE III-2

IMPACT OF DISASTER: A CONTINUUM OF EFFECTS



(adapted from Bowden and Kates, 1974)

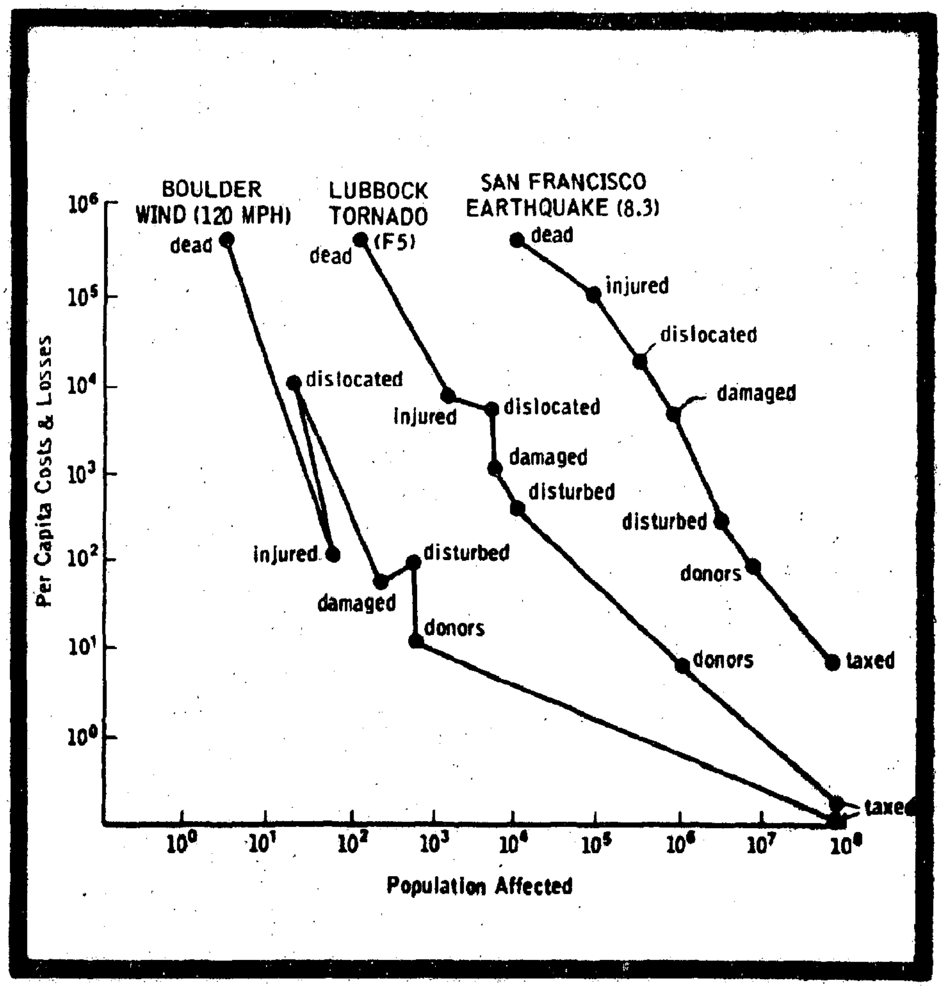


FIGURE III-3

IMPACT OF DISASTER FROM WIND, TORNADO AND ANTICIPATED EARTHQUAKE (Cochrane, 1975)

1) Awareness and efficacy

Making citizen groups aware of the hazard of a natural event does not necessarily lead to any positive action in coping with the hazard. It is always equally important for both the citizens and the responsible public agencies to be aware of the efficacy of some action which they can take in coping with the situation. Where people feel there is little that they can do to cope with a threat they may resort to denying its existence or to claiming that it is of relatively little importance. Their response to threats to life may be different from threats to property.

With any statement of the existence of a hazard, it is desirable to find ways of associating an outline of the kinds of practical action that may be taken in responding to it. For example, people who receive a warning of a flash flood or of an impending hurricane or storm surge will be more likely to take action if the warning includes specific suggestions of how they may be effective in the emergency or indication of what happens when they take action.

The California Division of Emergency Services has a series of radio and TV broadcasts which indicate the kinds of effective actions that can be taken upon feeling the first tremors of an earthquake. These are emergency actions, but they can be linked, with benefit, to discussions of land use in the hazard areas, and steps which can be taken in building design or other channels to reduce vulnerability to losses.

Wherever practicable a description of a vulnerable area should be linked with information about the availability of warning systems. This helps to remind the citizens concerned of the reality of the threat.

It is desirable to associate a statement about vulnerability to a natural hazard with outlines of the kinds of responses which people can make to the hazard when they recognize its full dimension. This would include information about the availability of flood or earthquake insurance, or of steps which could be taken upon experiencing an earthquake.

2) Modes of disseminating hazard information

There is a large and rapidly growing body of information and avenues available for disseminating information about hazards and ways of coping with them. It has been common to disseminate this information primarily through maps and brochures published by responsible agencies. Major producers of these are the National Oceanic and Atmospheric Administration, the Corps of Engineers, the U.S. Geological Survey, and the Federal Insurance Administration. Each is prepared to pass on the information upon request (see Section VI for names and addresses). A state agency can get the technical information from the agencies by special inquiry or arrangement.

There are, however, other networks which may be used to good advantage. One example is the Texas Coastal and Marine Resources Council which disseminates its own set of maps and brochures for distribution to interested citizens and citizen groups. The targets of such information should include individuals or non-government agencies concerned with decisions about land use management. Quite aside from property owners or tenants of properties, examples of groups which should be involved are:

Local and state associations of land appraisers;
Mortgage officers;
Savings and loan officials;
Officers of consumer safety agencies;
Officers of consumer protection groups;
Public school curriculum supervisors;
Radio and TV stations;
Newspapers;
Defense Civil Preparedness Agency and local Civil Defense officials;
Environmental quality organizations;
Architects and building design engineers;
Legal advisors to land use planning;
Associations of city and county building officials;
Local chapter of property insurance insurors;
Public utility companies;
Labor organizations;
Industrial plants maintaining in-plant information services.

Placing information about the hazard in the hands of citizens does not necessarily guarantee constructive public action. It is important to:

1) Select networks of citizens who are in a position to make decisions about permissible uses and sites, and

2) Suggest the range of potentially effective actions available to them.

In planning for the dissemination of information about hazards it is desirable to analyze the principal groups which have some role in making decisions about future use of the hazard area, and messages should be designed to be used specifically by those groups.

> *Inquiries should be made to ascertain which channels of information about a hazard have higher credibility in the view of people for whom the information is designed. Thus, in areas where citizen organizations or volunteer groups are more credible than representatives of Federal and state agencies, it may be desirable to enlist their participation and service in contributing and disseminating information and providing for a critical review of statements prepared for the public.*

A large proportion of populations in some hazard areas are new arrivals and lack experience with extreme events of infrequent occurrence. One of the classic cases is that of the population of areas subject to infrequent hurricane winds and storm surges along the Atlantic and Gulf coasts. The accompanying Figure III-4 illustrates, for a sample county in New Jersey, the proportion of population which has moved into the area since the most recent destructive hurricane. The increases are accounted for by normal growth and by in-migration from areas free of hurricanes.

In preparing plans for dissemination of information about hazards it is important to design the presentation of the evidence so that it will be intelligible to both the experienced population and to the newcomers without that experience.

3) <u>Methods of presenting the options and choice</u>

The more common and formal methods of involving citizens in Federal planning, construction, and management in coastal areas, as encouraged by the Act, are hearings on proposed projects for construction or acquisition. These include projects for Federal contributions for beach erosion control, protection works against hurricane storm surge, and acquisition of property for national parks and seashore.

The Corps of Engineers has experimented with methods of holding such hearings more than most other agencies. Some of their methods and experience deserve consideration, particularly where a vigorous effort has been made to involve local groups (Institute of Water Resources, 1975). In addition to the conventional type of formal hearing in which a draft report or statement of project investigation is circulated and in which public officials and citizens are invited to make public statements, there is opportunity to a) organize special discussion groups, b) circulate background material for consideration by informal groups in the community, and c) conduct polls of preferences, and the like. The relative effectiveness of these various measures is not well established. There is some reason to believe that a properly organized hearing may yield as representative a view of local interests as the other devices. A less conventional mode of community review does not necessarily lead to different expression of views or to a different decision on the part of the community than would have come from a standard type of hearing (Heberlein, 1975).

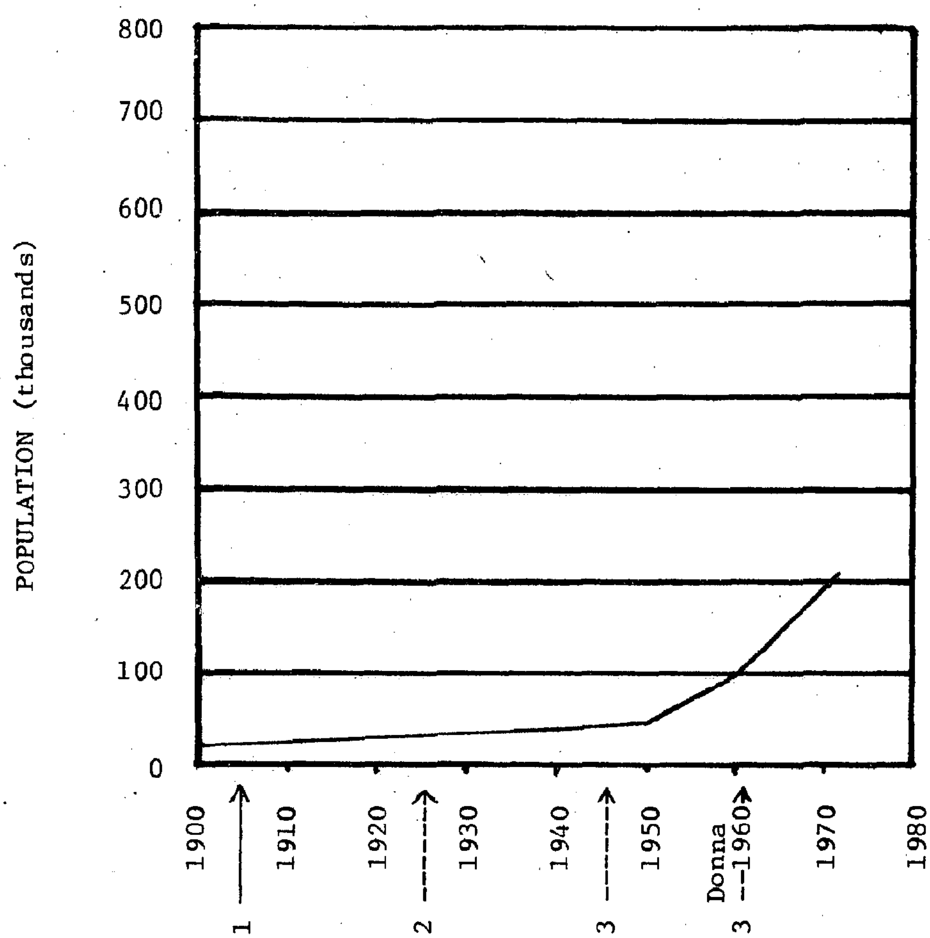
Studies of citizen response to plans for beach erosion management along the eastern seaboard indicate that a relatively small number of citizens in the affected communities took part, but of those who did, the most clearly concerned were the local commercial merchant community and the year-round residents as noted in Section II.

It is important to identify and evaluate the various media and channels that can be used to present options and choice to public groups. Whether or not the hearings mechanism, in contrast to discussion groups, conferences, or individual communications, is more effective depends upon local circumstances. It should not be assumed that a public hearing is the most effective means, but neither should it be dismissed without a careful examination of the other alternatives and their relative cost and efficiency.

Figure III-4

POPULATION GROWTH IN A NEW JERSEY COASTAL COUNTY,
AND HURRICANE OCCURRENCE, 1900-1970

OCEAN COUNTY, NJ



NOTE:

1 → Direct Hit by a Category 1 Hurricane
(1) = winds from 74-95 mph, storm surge 4-5' above normal

2 --→ Indirect Hit by a Category 2 Hurricane
(2) = winds from 96-110 mph, storm surge 6-8' above normal

3 --→ Indirect Hit by a Category 3 Hurricane
(3) = winds from 111-130 mph, storm surge 9-12' above normal

D. Organization and Coordination

After a hazard zone has been delineated in some fashion and the likely social impacts of a possible set of adjustments have been estimated, the task is to select suitable management tools. This involves economic, administrative, and legal questions. The legal questions arising in coastal areas are reviewed in Appendix B. Among the key issues are those relating to public acquisition of land and water rights, land regulation for health, safety, and welfare, and wetlands protection. The principal problems involved at this stage of coastal zone management are encouraging the organization of appropriate state and local agencies, coordinating land and water management with emergency planning for disasters, and coordinating the work with other Federal programs.

1) Encourage organization of appropriate state or local agencies

In a number of coastal situations it is unlikely that any adjustments to hazard, such as cooperative activity in stabilization of dune areas, will take place unless there is appropriate local organization of agencies with authority to assess taxes and to make expenditures for those purposes. They may carry the danger of splintering and duplicating existing agency programs. For these reasons, a basic step in outlining the options which are open to a community may be to describe the legislative or judicial measures which would be necessary to organize a local district, and the grounds on which they could be justified in going through the appropriate state and county procedures. Regional Councils of Governments may be one instrument for making this type of review.

Descriptions of proposed changes in the mix of adjustments to hazard should assess the need for organization of state or local agencies with the necessary powers to promote the new work.

2) Coordination with emergency planning for disasters

Every state in the coastal zone has a state organization which is responsible for preparing disaster preparedness plans. (See list in Section VI.) These plans include not only the marshalling of emergency services, but also the organization of measures to mitigate the prospective disaster and to guide the activities of rehabilitation and reconstruction to promote later mitigation and preparedness.

Under Section 201 of the Disaster Preparedness Act of 1974 specific authorization is given to the Administrator of the Federal Disaster Assistance Administration (FDAA) to support studies in each of the states applying for such help, to the extent of $250,000, for the preparation of disaster preparedness plans, including steps for the mitigation of potential disasters. The wording of the Act is as follows:

> SEC. 201. (a) The President is authorized to establish a program of disaster preparedness that utilizes services of all appropriate agencies (including the Defense Civil Preparedness Agency) and includes--

(1) preparation of disaster preparedness plans for mitigation, warning, emergency operations, rehabilitation, and recovery;

(2) training and exercises;

(3) postdisaster critiques and evaluations;

(4) annual review of programs;

(5) coordination of Federal, State, and local preparedness programs;

(6) application of science and technology;

(7) research

(b) The President shall provide technical assistance to the States in developing comprehensive plans and practicable programs for preparation against disasters, including hazard reduction, avoidance, and mitigation; for assistance to individuals, businesses, and State and local governments following such disasters; and for recovery of damaged or destroyed public and private facilities.

(c) Upon application by a State, the President is authorized to make grants, not to exceed in the aggregate to such State $250,000, for the development of plans, programs, and capabilities for disaster preparedness and prevention. Such grants shall be applied for within one year from the date of enactment of this Act. Any State desiring financial assistance under this section shall designate or create an agency to plan and administer such a disaster preparedness program, and shall, through such agency, submit a State plan to the President, which shall--

(1) set forth a comprehensive and detailed State program for preparation against and assistance following emergencies and major disasters, including provisions for assistance to individuals, businesses, and local governments; and

(2) include provisions for appointment and training of appropriate staffs, formulation of necessary regulations and procedures, and conduct of required exercises.

(d) The President is authorized to make grants not to exceed 50 per centum of the cost of improving, maintaining and updating State disaster assistance plans, except that no such grant shall exceed $25,000 per annum to any State.

As of September, 1976, all but one state had applied for and received funds for these studies and were in various degrees of execution.

Although the current Section 201 of planning is focused primarily on preparedness for response to disaster in accordance with policy instructions from the FDAA, the mechanism which has been established is intended to deal with mitigation, and must in the long term take account of possible measures to prevent rather than act in the trail of natural disaster. For this reason, the State emergency services agencies have the possibility of supporting and collaborating with efforts of management of hazards in coastal areas. Their state emergency plans may call the attention of state agencies and local communities to areas of special vulnerability. Their technical services may sharpen the work of local agencies in preparing to deal with a likely disaster. One way of focusing the the interest of local citizen groups and officials on the existence of a natural hazard and possible ways of coping with it is to identify a specific area as a potential disaster area and to suggest the emergency measures that will be necessary when the disaster occurs. This may promote public awareness and indicate the lines along which mitigation measures might ultimately move.

Most states have legislation, based upon the Council of State Government's model State Disaster Act, which specifies emergency powers and may go further in disaster mitigation. Thus, the Texas Disaster Act of 1975, modeled after the Council's, shifted the state policy toward minimizing and preventing damages. However, due to a desire to not infringe on local governments, many actions are only suggested; local politics may hinder the Act's effectiveness.

The Defense Civil Preparedness Agency (DCPA) of the Department of Defense is primarily responsible for civilian response to a nuclear attack, but it is also concerned secondarily with the effects of natural disaster. It could be useful in disseminating information about the threat from and preparedness for such events.

> *Wherever the hazard of extreme natural events carries the likelihood of severe damage to life or property, arrangements should be made with the state emergency services agency for designation of the area likely to be involved, and for the preparation of plans for emergency action if and when the event occurs. In some areas it may be necessary to call the vulnerable zone to the attention of the state emergency services agency while in other areas it may be sufficient to recognize that the emergency plans already have been drawn.*

In dealing with areas of high vulnerability to extreme natural events it should be recognized that the organization of a warning service and the training of people to participate in evacuation or other activities in response to warnings is one practical method of alerting the population to the risk which they are running and to the severity of possible disruption when an event occurs. A coastal zone management office may be strengthened when the state emergency agency designs and repeats disaster warnings and evacuation operations, and trains personnel in agencies and citizen groups to respond to them.

Unless there is a preliminary plan for land use development at the time that an extreme event occurs, long-term rehabilitation is not likely to follow a pattern radically different from that which prevailed before the disaster. The typical experience (as exemplified by the City of Anchorage, Alaska following the 1964 earthquake) is that the town rebuilds in the same location. However, in the case of Rapid City, South Dakota, following the flood of 1972, large scale methods of rehabilitation were achieved in considerable measure because the city had already undertaken a plan for redevelopment of the flood plain area which had long been known to carry the seeds of disaster.

The success of Hilo, Hawaii in adopting open space uses after the 1960 tsunami may be attributed to a high level of awareness of the hazard, relatively frequent tsunami occurrence in the area, strong state and Federal leadership, development of a comprehensive reconstruction plan, availability of undeveloped public lands for the relocations and availability of Federal funds (especially urban renewal) (see Marx, 1974).

3) <u>Coordination with related Federal programs</u>

In coastal areas with a relatively high risk from extreme natural events, it may be helpful in advancing a program of land and water use management to call to the attention of interested Federal agencies the ways in which this vulnerability relates to their long-term missions. Some of the direct linkages which may be taken into account in preparing land and water management plans are those which relate to the occupational safety and health activities of the Federal government, the executive policy with respect to occupation of flood hazard areas, and the appraisal of hazards related to energy power installations.

Under the terms of the Occupational Safety and Health Act, the Federal administration has responsibility for overseeing the location, design and operation of industrial enterprises insofar as they carry the possibility of exposing workers to occupational hazards. As of 1976 the OSHA administration had paid relatively little attention to the implications of location of new industrial sites in areas of natural hazard, but this may be regarded as a responsibility which will be examined with more care after OSHA copes with the more direct questions of accident prevention within industrial plants.

One aspect of the problem with which OSHA already has begun to deal is that of the appropriate design of mobile homes which are highly subject to damage from high winds, storm surge, and floods. Where mobile homes are a significant part of the residential use of a hazardous area it may be desirable to request that OSHA give consideration to the regulations affecting the design, anchorage and installation of new units.

> *For each area vulnerable to extreme natural events in which economic development is in prospect a description of the hazard should be presented to the regional Office of OSHA.*

Executive Order 11296 requires all Federal agencies responsible for construction or administration of grant, loan, or mortgage insurance programs to give attention to the possibility of damage from fresh water flooding in the construction, installation and modification of Federal facilities in flood plains. The order reads as follows:

Executive Order 11296

EVALUATION OF FLOOD HAZARD IN LOCATING FEDERALLY OWNED OR FINANCED BUILDINGS, ROADS, AND OTHER FACILITIES, AND IN DISPOSING OF FEDERAL LANDS AND PROPERTIES

WHEREAS uneconomic uses of the Nation's flood plains are occurring and potential flood losses are increasing despite substantial efforts to control floods; and

WHEREAS national and regional studies of areas and property subject to flooding indicate a further increase in flood damage potential and flood losses, even with continuing investment in flood protection structures; and

WHEREAS the Federal Government has extensive and continuing programs for the construction of buildings, roads, and other facilities and annually disposes of thousands of acres of Federal lands in flood hazard areas, all of which activities significantly influence patterns of commercial, residential, and industrial development; and

WHEREAS the availability of Federal loans and mortgage insurance and land use planning programs are determining factors in the utilization of lands:

NOW, THEREFORE, by virtue of the authority vested in me as President of the United States it is hereby ordered as follows:

Section 1. The heads of the executive agencies shall provide leadership in encouraging a broad and unified effort to prevent uneconomic uses and development of the Nations's flood plains and, in particular, to lessen the risk of flood losses in connection with Federal lands and installations and federally financed or supported improvements. Specifically:

(1) All executive agencies directly responsible for the construction of Federal buildings, structures, roads, or other facilities shall evaluate flood hazards when planning the location of new facilities and, as far as practicable, shall preclude the uneconomic, hazardous, or unnecessary use of flood plains in connection with such facilities. With respect to existing Federally owned properties which have suffered flood damage or which may be subject thereto, the responsible agency head shall require conspicuous delineation of past and probable flood heights so as to assist in creating public awareness of and knowledge about flood hazards. Whenever practical and economically feasible, flood proofing measures shall be applied to existing facilities in order to reduce flood damage potential.

(2) All executive agencies responsible for the administration of Federal grant, loan, or mortgage insurance programs involving the construction of buildings, structures, roads, or other facilities shall evaluate flood hazards in connection with such facilities and, in order to minimize the exposure

of facilities to potential flood damage and the need for future Federal expenditures for flood protection and flood disaster relief, shall, as far as practicable, preclude the uneconomic, hazardous, or unnecessary use of flood plains in such connection.

(3) All executive agencies responsible for the disposal of Federal lands or properties shall evaluate flood hazards in connection with lands or properties proposed for disposal to non-Federal public instrumentalities or private interests and, as may be desirable in order to minimize future Federal expenditures for flood protection and flood disaster relief and as far as practicable, shall attach appropriate restrictions with respect to uses of the lands or properties by the purchaser and his successors and may withhold such lands or properties from disposal. In carrying out this paragraph, each executive agency may make appropriate allowance for any estimated loss in sales price resulting from the incorporation of use restrictions in the disposal documents.

(4) All executive agencies responsible for programs which entail land use planning shall take flood hazards into account when evaluating plans and shall encourage land use appropriate to the degree of hazard involved.

Sec. 2. As may be permitted by law, the head of each executive agency shall issue appropriate rules and regulations to govern the carrying out of the provisions of Section 1 of this order by his agency.

Sec. 3. Requests for flood hazard information may be addressed to the Secretary of the Army or, in the case of lands lying in the basin of the Tennessee River, to the Tennessee Valley Authority. The Secretary or the Tennessee Valley Authority shall provide such information as may be available, including requested guidance on flood proofing. The Department of Agriculture, Department of the Interior, Department of Commerce, Department of Housing and Urban Development, and Office of Emergency Planning, and any other executive agency which may have information and data relating to floods shall cooperate with the Secretary of the Army in providing such information and in developing procedures to process information requests.

Sec. 4. Any requests for appropriations for Federal construction of new buildings, structures, roads, or other facilities transmitted to the Bureau of the Budget by an executive agency shall be accompanied by a statement by the head of the agency on the findings of his agency's evaluation and consideration of flood hazards in the development of such requests.

Sec. 5. As used in this order, the term "executive agency" includes any department, establishment, corporation, or other organizational entity of the executive branch of the Government.

Sec. 6. The executive agencies shall proceed immediately to develop such procedures, regulations, and information as are provided for in, or may be necessary to carry out, the provisions of Sections 1, 2, and 3 of this order. In other respects this order shall take effect on January 1, 1967.

LYNDON B. JOHNSON

THE WHITE HOUSE
August 10, 1966

(F.R. Doc. 66-8838; Filed, Aug. 10, 1966; 12:14 p.m.)

A proposed revision of the order was under consideration in November, 1976.

A report from the General Accounting Office regarding national attempts to reduce flood losses (GAO, 1975) indicated that Federal agencies have been less than diligent in some cases in complying with the order.

Wherever there is prospect of Federal investment in a flood hazard area, the attention of the responsible Federal agency should be called to the provisions of Executive Order 11296 and a request should be made that it make an explicit statement of the way in which it has complied with the order.

Decisions involving the construciton, expansion, or operation of coastal energy facilities whether for exploration, development, production, conversion, storage or transportation, require that the potential risk to such facilities from natural hazards be evaluated. A detailed statistical analysis of the potential risk to nuclear power plants from technological accidents, nuclear accidents, and natural hazards, was published in 1975 by the Nuclear Regulatory Commission Reactor Safety Study (NRC, 1975).

Whenever there is the possibility of energy facility development within the coastal area an assessment of potential impact from natural hazards should be made.

Other linkages with the programs of Federal agencies may be developed. These three examples are not intended to be a complete listing of the opportunities.

The net effect of the recommendations presented in this Section is to focus attention upon the role of natural hazards in arriving at decisions about the use of coastal areas. State management efforts may contribute to wiser adjustments to the risk of extreme events. In turn, realistic appraisal of hazards and ways of dealing with them may strengthen the programs to manage the nation's coasts.

REFERENCES

Baker, E.J., A Longitudinal Assessment of Attitudes toward Hazard Zone Regulations. Technical Paper No. 2, Tallahassee: Florida Resources & Environmental Analysis Center, Florida State University, 1976.

Baker, E.J., "Some Problems in Evaluating Land Use Policy Alternatives," Proceedings of the Association of American Geographers, 7, 32-36, 1975.

Baker, E.J., Toward an Evaluation of Policy Alternatives Governing Hazard-Zone Land Uses. Natural Hazard Research Working Paper 28, Boulder: University of Colorado, Institute of Behavioral Science, 1976.

Barlowe, Raleigh, Land Resource Economics. Englewood Cliffs, NJ: Prentice-Hall, 1972.

Bowden, M.J. and R.W. Kates, "The Coming San Francisco Earthquake: After the Disaster" in Cochrane, et al., Social Science Perspectives on the Coming San Francisco Earthquake. Natural Hazard Working Paper 25, Boulder: University of Colorado, Institute of Behavioral Science, 1974.

Brown, et al., Natural Hazards of the Texas Coastal Zone. Bureau of Economic Geology, Austin: University of Texas, 1974.

Cochrane, H., Natural Hazards and Their Distributive Effects. Boulder: University of Colorado, Institute of Behavioral Science, 1975.

Ericksen, Neil, Scenario Methodology in Natural Hazards Research. Boulder: University of Colorado, Institute of Behavioral Science, 1975.

Heberlein, Thomas, Principles of Public Involvement. Prepared for the National Park Service, U.S. Department of Interior, 1975.

Hebert, Paul J. and Glenn Taylor, Hurricane Experience Levels of Coastal County Populations-Texas to Maine. U.S. Department of Commerce, NOAA, NWS, July, 1975.

Hill, M., "A Goals-Achievement Matrix for Evaluating Alternative Plans," Journal of the American Institute of Planners, 34, 19-29, 1968.

Howe, C., Benefit-Cost Analysis for Water System Planning. A.G.U. Water Resources Monograph #2, American Geophysical Union, Washington, 1971.

Marx, Wesley, "Graceful Retreat from the Battering Ram of Hilo's Tsunamis," Landscape Architecture 64, 153-158, April, 1974.

Mathewson, C.C. and D. P. Piper, "Mapping the Physical Environment in Economic Terms," Geology, November, 627-629, 1975.

McHarg, I., Design with Nature. Garden City, NY: Doubleday/Natural History Press, 1969.

Nuclear Regulatory Commission, Reactor Safety Study: An Assessment of Accident Risks in U.S. Commercial Nuclear Power Plants. Main Report, U.S. Department of Commerce, NTIS, PB 248 201, October, 1975.

Rinehart, W., S.T. Algermissen and Mary Gibbons, <u>Estimation of Earthquake Losses to Single Family Dwellings</u>. U.S. Department of Interior, U.S. Geological Survey Open File Report, 76-156.

U.S. General Accounting Office, <u>National Attempts to Reduce Losses From Floods by Planning For and Controlling the Uses of Flood-Prone Lands</u>. Comptroller General of the U.S. Washington, March 7, 1975.

U.S. Institute of Water Resources, <u>Structuring Communications Programs for Public Participation in Water Resources Planning</u>. U.S. Army Engineer Institute for Water Resources, Ft. Belvoir, Virginia, 1975.

White, Gilbert F. and J. Eugene Haas, <u>Assessment of Research on Natural Hazards</u>. Cambridge, MA: MIT Press, 1975.

SECTION IV

HAZARD MANAGEMENT IN THE COASTAL STATES

IV. HAZARD MANAGEMENT IN THE COASTAL STATES

No state has thus far explored and tested the whole range of legislative and administrative measures available for managing hazards along its coast. Some states are far ahead in experimenting with control through land-use tools. Others are beginning to appraise the options open to them.

A summary review of the current management in each of the states serves two major purposes:

1. Agencies and interested groups in each state can check to see whether or not their appraisal of the occurrence, extent and threat of each type of hazard is similar to that of national and scientific observers.

2. They can learn whether or not other states are carrying on activities which might be applied with benefit along their own coast.

This will help put the individual state's conditions in national perspective. And it will point out lessons which may be learned from others.

The current hazard management activities in the 30 coastal states are summarized in tabular and text form in this section. The section does not pretend to be a complete and comprehensive report on all activities now underway. Nor does it describe in detail the status of hazard adjustment in each of the states. It does offer a succinct and brief review of what is known about the existence of hazard from extreme events along the coast, and an outline of the ways in which Federal, state and local agencies cope with these hazards. The text reviews the situation state by state and is supported by a table which gives more details and reference to publications of special significance to that state.

The reader wishing to obtain an overview of the natural hazards situation in the coastal zone of any one of the states is encouraged 1) to read the text; 2) to examine the tabular material; 3) to go to the more detailed sets of information in the references.

Some of the references are included in the annotated bibliography, principally those with broader applicability to national conditions.

It is possible to extract from the text and accompanying tables an overview of:

Location of Vulnerable Areas - Which sections or types of coast are estimated in national surveys to be prone to each type of extreme event.

Character and Frequency of Extreme Events - Readily available information pertaining to times and magnitude of occurrence of each type of extreme event.

Effects - Summary of available data on social and environmental consequences of past events.

Future Susceptibility - Estimates of prospects for future damages, including trends in amount and type of social effects.

Responsible Agencies - Brief reference to major agencies at the national, state, and local levels exercising responsibility for some aspect of hazard management in the coastal zone.

Legislative Authorities - Institutional Arrangements - The chief authorities under which these agencies act, and the institutional arrangements they maintain.

Administrative Regulations and Policies - Comments on the regulations and policies which are followed by these agencies as they apply to coastal hazards problems.

Wherever appropriate a reference is made to sources of information and estimates.

ALABAMA

There are 607 miles of tidal shoreline in the Alabama coastal zone (U.S. Dept. of Commerce, 1971)*. The Gulf of Mexico coastline includes 46 miles of sandy beach; bays and estuaries comprise the remaining 561 miles.

The Alabama coastal zone is subject to hurricanes, coastal erosion and coastal flooding.

Although a major hurricane has not hit the area directly since 1976, the annual probability for a hurricane along parts of the Alabama coast has been estimated to be quite high, at thirteen per cent (13%) (Simpson and Lawrence, 1971). Hurricanes generally cause serious storm surge and high wind conditions which in turn may cause coastal flooding and erosion. In those coastal areas which are currently experiencing population growth and increased development, erosion, accretion and sedimentation may pose a menace.

Flooding is another natural hazard of concern in the Alabama coastal zone. Such flooding may be the result of storm surge conditions during precipitation associated with storm or hurricane systems.

Table IV-1 shows the nature of the natural hazards in the Alabama coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The heart of natural hazard management in the Alabama coastal zone lies within the Coastal Zone Development Act of 1976 which assigns the Coastal Area Board to develop a comprehensive plan for management of the coastal zone.

Although the Coastal Zone Development Act charges the Coastal Area Board with developing a permitting program for Areas of Particular Concern, the law does not specify criteria for designation, and the Board has not yet developed the standards.

Excessive erosion areas will probably be included in the Areas of Particular Concern, but presently the main adjustment is structural.

*Shoreline figures include: shoreline of outer coast, offshore islands, sounds, bays, rivers and creeks to head of tidewater or to a point when tidal waters narrow to a width of 100 feet. These figures conform to NOAA's definition of "Tidal Shoreline" (U.S. Dept. of Commerce, 1971).

TABLE IV-1

NATURAL HAZARD MANAGEMENT IN THE ALABAMA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Entire coast vulnerable.	6-13% probability of hurricane effects in any year. 0-1% probability of a great hurricane landfall. See Ref. 41 1% probability of a 13 ft. storm surge in Mobile. See Ref. 41 1900-1974 - 7 hurricanes; 3 were great hurricanes. See Ref. 13 Major events: 1906, 1916, 1917, 1926.	Accelerated erosion, flooding, wind, storm surge, tornadoes. Potential for substantial loss of life & property, especially in Mobile & Dauphin Island areas.	63.8% population increase since last major hurricane. See Ref. 13 Inexperience of population may hinder evacuation. Increasing development of hazard area adds to vulnerability.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) Alabama Dept. of Civil Defense	Construction of storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
Coastal Erosion	9% critically eroding, 32% noncritical erosion, 59% stable. See Ref. 55 Especially vulnerable: Dauphin Island & parts of Mobile Bay.	Chronic but accelerated by storms.	Damages beaches, protective works, buildings, roads, etc. Sedimentation & island migration may cause navigation hazards.	Could be major problem, especially on Dauphin Island.	U.S. Army Corps of Engineers Coastal Area Board U.S. Federal Insurance Administration	Study coastal erosion problems, plan & construct erosion control structures. Board given responsibility to develop, coordinate & maintain coastal area program. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coastal Zone Development Act (1976). Coverage limits are the same as for coastal flooding.
Coastal Flooding	Poorly drained coastal areas.	Flooding caused by hurricane & local storms. High rainfall causes general flooding on the average once every 10 years. Localized flooding occurs several times a year. See Ref. 56 Not a major problem, except in poorly drained areas. Tombigbee River - 9 major floods 1900-1952. See Ref. 15	Generally slight damage.	Slowly increasing with development in flood plain.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration. Alabama Development Office County Commissions U.S. Geological Survey County Flood Insurance Program Coordinator Alabama Dept. of Civil Defense Coastal Area Board	Study coastal flood problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Program. Principal planning agency of the state. Adopt comprehensive management & use programs for flood-prone areas in unincorporated territory. Prepare flood-prone area maps. For unincorporated flood-prone areas; adopt land use & control measures, subdivision regulation, building codes, & zoning measures to make flood insurance available as provided by the NFIA of 1968. Assist local governments in emergency and disaster situations. Board given responsibility to develop, coordinate, & maintain coastal area program.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Distributes HUD planning funds, Office of Coastal Zone Management funds, offers technical assistance to local governments in zoning, flood insurance program. Coastal Zone Development Act (1976).

ALASKA

With 33,904 miles of coastline (more than 4,000 of open beach) (U.S. Dept. of Commerce, 1971), Alaska faces a set of coastal hazards unmatched both in intensity and number elsewhere in the United States.

The Alaskan coastline is rimmed by some of the stormiest seas in the world. Mountains rise directly from tidewater throughout much of southern Alaska, so that hazards of the Alpine environment merge with hazards of the coastal zone. The southcentral coastal region and the Aleutian Chain are in one of the highest seismic risk zones in the world and include seventy-six volcanoes, several of which have had major eruptions during this century. Given the dependence of Alaskans on the sea for much of their livelihood and transportation, the proportion of population-at-risk from coastal hazards will probably always be much higher in Alaska than in other states.

Severe winter storms, often accompanied by icing conditions, are a regular winter occurrence along Alaska's coasts, causing a hazard both to navigation and to people and facilities ashore. Such storms contribute to coastal erosion and coastal flooding problems. Coastal erosion is a problem along the Alaska coastline, particularly along the western and Arctic coasts where much of the coastline is composed of unconsolidated sediments of weakly lithified rock. Forty-six coastal communities report severe to moderate erosion problems, either from wave or fluvial action (U.S. Army Corps of Eng., 1973).

The flood hazard is also widespread along the Alaskan coast. Storm surge, river overflow, and ice ponding, separately or in combination, create flood hazards in numerous locations. Southern Alaska records the heaviest precipitation on the North American continent. Riverine flooding is inevitable under such conditions.

The southern Alaskan coast is one of the most earthquake prone areas in the United States, recording 714 quakes, an average of eighty-nine per year, between 1965 and 1972. The largest recorded Alaskan earthquake was March 27, 1964, with a magnitude of 8.4 to 8.6 on the Richter scale. It took 130 lives and caused $300 million in property damage. There were 587 aftershocks.

Among the secondary hazards which were associated with the 1964 earthquake were rockslides, avalanches, subaqueous slides, local sea waves, and a disastrous tsunami, seismic sea wave, which hit the coast approximately one hour after the initial earthquake and was responsible for ninety per cent (90%) of the deaths. Although the 1964 tsunami received great attention, many others have been recorded in recent time. The most vulnerable regions are the Aleutians and the south central coast (Alaska Dept. of Environmental Conservation, 1976). Landslides are commonly triggered by earthquakes or heavy precipitation, both common in the

Alaskan coastal zone.

Similarly avalanches may be triggered by seismic disturbances, and the 1964 quake is said to have caused 2000 avalanches. Avalanches, though typically a hazard in mountainous regions, also become a coastal hazard in Alaska because of the intimate association of mountains and sea. They are a function of slope and snow accumulation, and are often triggered by sharp changes in temperature, by wind and by earthquake. Avalanches tend to run on established paths which can be identified by the absence of large trees and by other evidence of scouring. Avalanches are especially large and powerful in southern Alaska because of the large scale of the topography and heavy snowfall. While the potential for a major avalanche disaster exists, only eleven avalanche fatalities have occurred in Alaska between 1950 and 1975.

There are seventy-six known volcanoes in a 1600-mile arcuate zone stretching from Mt. Spurr on the west side of Cook Inlet near Anchorage to Attu Island at the western end of the Aleutian Chain, plus several located outside this zone. During 200 years of recorded Alaskan history, 250 separate eruptions have occurred at thirty-nine volcanoes, the most violent being the 1912 eruptions of Katmai and Novarupta which damaged buildings, crops, and other vegetation at Kodiak, with traces of ash falling in Juneau, 750 miles away (Alaska Dept. of Environmental Conservation, 1976). The greatest threat from volcanoes in the coastal zone is that of mudflows and sea waves which may be generated by the volcanic activity.

Table IV-2 shows the nature of the natural hazards in the Alaska coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures. Local governments possess adequate authority to control land use, but are not compelled to do so. At present, no legislative authority exists for shoreline management at the state level. Hazard management is, at best preliminary, concentrated primarily at the inventory level.

TABLE IV-2

NATURAL HAZARD MANAGEMENT IN THE ALASKA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	46 communities report severe to moderate erosion problems. See Ref. 1 Of 33,904 miles of shoreline: 10% noncritically eroding, 90% stable. See Ref. 54	Continual process accelerated by storm waves, high water, ice action & permafrost failure. Maximum activity is in winter. Varying rates of recession - 10 ft./year at Pt. Barrows, 50 ft./year at Icy Bay. See Ref. 48	Threatens a number of roads & buildings; has cuased the relocation of several communities.	Some reduction in susceptibility possible with better land use controls.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Organized Boroughs & Municipalities	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damage from accelerated erosion. May identify & plan for hazard zones, establish zoning ordinances, building codes & land use management programs.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding. No state law currently exists requiring adoption of these measures.
Coastal Flooding	Low-lying areas on open coast, estuaries & many localized areas on inland waters & stream mouths.	Flooding caused by snow melt, storm surges, ice ponding & high rainfall (32.18 in. rain near Kodiak in Nov. 1959). Possible dam failures & scarcity of building sites add to problem. Major floods in state: 1946, 1951, 1953, 1967, 1968, 1969, 1971. See Ref. 56	Heavy property damage, but little loss of life. May cause disruption of trade & transportation, isolation of some areas.	Increasing development of low-lying areas adds to flood vulnerability.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Local Governments Alaska Disaster Office Organized Boroughs & Municipalities	Study coastal flooding problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Issue zoning regulations, building codes & land use management regulations. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. May identify & plan for hazard zones, establish zoning ordinances, building codes & land use management programs.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288. No state law currently exists requiring adoption of these measures.
Earthquake	Expected damage: south coast - major; west-central coast - moderate; north coast - minor. See Ref. 2	1960-1970, about 30 modified Mercalli intensity V (or greater) earthquakes in coastal areas. See Ref. 59	Seismic activity may trigger avalanches, landslides, tsunamis, local waves & fires. 1964 earthquake, 8.4-8.6 on Richter scale, 130 dead (mostly from tsunami), estimated $400-500 million damage. See Ref. 59	Increasing development increases vulnerability, but some reduction is possible through better building and land use controls.	U.S. Geological Survey Alaska Disaster Office Organized Boroughs & Municipalities	Conducts geological studies in order to monitor & possibly predict seismic activity. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. May identify & plan for hazard zones, establish zoning ordinances, building codes & land use management programs.	Responsible under Sec. 201 of PL 93-288. No state law currently exists requiring adoption of these measures.
Tsunami	All open coasts & many inland areas vulnerable.	Impulsive disturbance in ocean generates a series of long waves. May be triggered by earthquakes, volcanoes, landslides, or avalanches. 30 ft. wave heights have been reported. Major events: 1878, 1929, 1938, 1946, 1957, 1964. See Ref. 1 Aleutians & south-central coast most vulnerable to local waves.	Origin of tsunami, magnitude, configuration of coast & extent of coastal development contribute to damage potential. High catastrophe potential. 1964 earthquake triggered tsunami, caused 103 deaths, $80 million damage in Alaska. See Ref. 2	Benefits of better land use planning & education may be offset by increased development on coast.	National Weather Service (NOAA) Alaska Disaster Office U.S. Federal Insurance Administration Organized Boroughs & Municipalities	Issues advisories & warnings. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Hazard area delineation, assist local governments with eligibility for flood insurance. May identify & plan for hazard zones, establish zoning ordinances, building codes & land use management programs.	Responsible under Sec. 201 of PL 93-288. See Ref. 31 No state law currently exists requiring adoption of these measures.

TABLE IV-2 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE ALASKA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Landslide	Mountainous & steeply sloped coastal areas.	May be triggered by earthquake, rain, man's activities.	Direct effects or may cause seiches & flooding. Damage concentrated in small area unless regional artery is destroyed (road, utility line).	Development of hazardous slopes contributes to damage potential.	U.S. Geological Survey Organized Boroughs & Municipalities	Research in landslide prediction through the Landslide Hazard Reduction Program. May identify & plan for hazard zones, establish zoning ordinances, building codes & land use management programs.	No state law currently exists requiring adoption of these measures.
Avalanche	Widespread in coastal mountains & are most common along the southern coast. Juneau is the most avalanche-prone city in the coastal zone.	Wet snow avalanches most common. Frequently depends on weather & triggering mechanisms. 1964 earthquake triggered many avalanches, contributing to a good planning base. See Ref. 45	Some hazard to life & property; damage localized unless utilities, transportation routes, etc. destroyed. Seiches caused by slides into narrow harbors. May flood extensive areas. Can temporarily dam streams, causing floods later.	Increasing where development occurs in avalanche tracks or hazardous areas. Possible large magnitudes make structural protective adjustments inadequate.	U.S. Forest Service Alaska Disaster Office Organized Boroughs & Municipalities	Basic avalanche research. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. May identify & plan for hazard zones, establish zoning ordinances, building codes & land use management programs.	Responsible under Sec. 201 of PL 93-288. No state law currently exists requiring adoption of these measures.
Volcano	76 known volcanoes in arc from Mt. Spurr near Anchorage to western end of Aleutian Islands Several others are outside this zone. See Ref. 1	Explosive eruptions most common; estimated 1 major eruption per 100 years. See Ref. 1 250 eruptions in 200 years from 29 volcanoes. Major event - 1912 eruption of Mt. Katmai. See Ref. 2	Tsunamis and ash falls are most hazardous volcano-related effects. Little development close enough to volcanoes to be affected by lava. Mud flows could endanger a number of semi-permanent establishments. Seiches may extend range of impact.	Increasing as development expands, especially along Cook Inlet.	U.S. Geological Survey Alaska Disaster Office Organized Boroughs & Municipalities	Monitoring & surveillance of individual volcanoes. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. May identify & plan for hazard zones, establish zoning ordinances, building codes & land use management programs.	Responsible under Sec. 201 of PL 93-288. No state law currently exists requiring adoption of these measures.

CALIFORNIA

California's coastal zone consists of 3,427 miles of shoreline, and includes parts of fifteen counties (U.S. Dept. of Commerce, 1971). Physically it includes rocky beaches, tall cliffs, sand dunes, forests, lagoons, swamps, marshlands, and tidal coves.

California's coastal zone, while geographically blessed with abundant diversity, also is afflicted by an abundance of natural hazards: earthquakes, tsunamis, landslides, coastal erosion and coastal flooding.

Earthquakes are a threat all along the fault-ridden coast of California, numerous minor and several major disturbances having been recorded during the past century. The secondary effects associated with earthquakes: fires, destruction of dams and resultant flash flooding, present serious hazards of their own to the heavily populated coastal regions.

Earthquakes generated deep beneath the Pacific Ocean or along the coast itself may result in tsunamis, sea waves, which can cause considerable property damage and loss of life. The area south of Santa Barbara is prone to tsunamis generated by seismic disturbances on land. Further north, Crescent City has suffered considerable damage seven times within the last decade as a result of tsunamis generated by distant submarine disturbances.

Coastal erosion, a problem along approximately 1/5 of California's shoreline, is deemed critical for approximately 4-1/2% of the coastline or 154 miles. Coastal flooding is also a serious hazard along the coastal zone of California. Numerous mountain streams drain the coastal zone to the ocean. During severe winter storms, heavy rain and strong winds may combine to cause serious flooding of these streams and damage to coastal property. Historically, many lives have been lost during such periods of severe coastal flooding (U.S. Army Corps of Eng., 1973b).

Landslides occur throughout much of the California coastal zone due to the instability of the prevailing geologic structures, the steep-canyon topography of the coastal ranges, earthquake ground shaking, and man-caused changes, such as cuts and fills on steep slopes. Fast mudflows, a natural phenomenon associated with steep topography, sparse vegetative cover, and torrential precipitation, are aggravated by fire-caused losses of stabilizing ground cover.

Table IV-3 shows the nature of the natural hazards in the California coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The central coordinating mechanism for hazards management in the California coastal zone has been the California Coastal Zone Conservation Act of 1972. This legislation established a temporary state commission to prepare a state coastal zone plan, as well as six regional coastal commissions to recommend elements of the state plan and to administer an interim permit program, for which the state commission would serve as a board of appeals. This permit program required that a permit be obtained for virtually any kind of land use, building, pollution discharge, or dredging and filling within 1000 yards of the shoreline, and was a stop-gap measure to hold the line until the state coastal zone plan could become operative. A large proportion of the permit applications submitted were approved, with or without conditions, but the program has exerted a substantial shaping force upon coastal zone development during its four year life span.

Successor legislation was enacted by the California legislature in August, 1976. The California Coastal Act of 1976, in general, adopts many of the provisions of the state coastal zone plan, creates a permanent state coastal zone commission, extends temporarily the life and permit authority of the regional commissions, and requires all units of government possessing authority for land use planning and control to bring their programs into conformity with the state coastal goals and guidelines of the Act. When this latter objective has been accomplished, or by June 30, 1979, the regional commissions and the interim state permit program will go out of existence. Thereafter, permits for developments in the coastal zone would be issued by local governments, under approved programs, or by the State Commission.

Many of the basic provisions of the California Coastal Act were inspired by the successful conservation and planning efforts of the Bay Conservation and Development Commission (BCDC). The BCDC was established in San Francisco in 1965 for preservation and planning of the Bay Shore area and eventually extended such efforts to the area's ocean coast, as well (Scott, 1975). BCDC has a very sophisticated hazards analysis procedure including a staff registered Engineering Geologist and an interdisciplinary panel of some of the most distinguished earth science people in the U.S. (Schoop, 1976).

TABLE IV-3

NATURAL HAZARD MANAGEMENT IN THE CALIFORNIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES - INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Earthquake	See Ref. 61 Coastal zone is part of earth-quake prone belt extending around the rim of the Pacific Ocean. Coastal zone includes numerous, complex fault zones.	Almost every section of California coast section has at one time experienced earthquakes. Their occurrence is still fairly unpredictable. Earthquakes of serious intensity have occurred in both San Francisco area (1906) & in San Fernando Valley (1971). Maximum modified Mercalli intensity expected is X-XII depending on location. See Ref. 44 7 earthquakes, modifed Mercalli intensity VIII or larger from 1950-1970. Ref. 59	1906 San Francisco earthquake, intensity XI, destructive intensity extended 400 miles. At least 700 dead, many millions of dollars damage. Ref. 59 Very serious property damage & widespread psychological trauma accompanied both serious earthquakes - which were compounded by fire & flooding.	Potential for coastal zone damage is great. Building code reduces future susceptibility somewhat, but many older buildings are not adequately protected.	U.S. Geological Survey	Conducts geological studies in order to monitor & possibly predict seismic activity.	
					State Division of Mines & Geology	Prepares maps of hazard zones for local government. Provides criteria for land use in hazard zones.	No structures permitted within 50 feet of active fault. Geologic report required for development within 660 feet of fault.
					State Office of Emergency Services	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans & encourage local land use & construction techniques to reduce hazard potential.	Responsible under Sec. 201 of PL 93-288.
					State Coastal Commission/Regional Coastal Commissions	See attached note.	
					Local Governments	Enact & enforce building codes which may incorporate earthquake-resistant construction standards. See attached note.	Uniform Building Code provides standards for grading & earthquake-resistant design.
					Port Governing Bodies	See attached note.	
Tsunami	Most of coast-line is vulnerable; primary area of vulnerability to tsunamis generated in Pacific Ocean is coast north of Point Conception. Santa Barbara & Santa Monica more susceptible to locally generated tsunamis. See Ref. 7	Large scale seismic sea waves are generated by submarine disturbances resulting in large sea waves which are destructive to areas immediately adjacent to coastline. See Ref. 2	Crescent City has experienced 7 tsunamis since 1964. See Ref. 56 Destruction to coastal areas of Santa Monica & Santa Barbara from locally generated tsunami.	Increasing development of coastal area & inexperience with hazard in many areas contributes to damage potential.	U.S. Army Corps of Engineers	Prepares maps of tsunami run-up zones.	Hazard zone defined by 100 year recurrence interval.
					National Weather Service (NOAA)	Collects & disseminates meteor-ological information. Issues tsunami warnings.	
					U.S. Federal Insurance Administration	Administers National Flood Insurance Program.	
					State Coastal Commission	Prepares state coastal zone plan. May consider appeals of permit actions of regional commissions. See attached note.	Planning zone includes coastal watersheds or 5 miles inland from mean high tide line.
					Regional Coastal Commissions	See attached note.	
					Local Governments	See attached note.	
					Port Governing Bodies	See attached note.	
					State Division of Mines & Geology	Defines areas vulnerable to tsunami hazard.	
					State Office of Emergency Services	Responsible for disaster planning & on-site assistance.	

TABLE IV-3 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE CALIFORNIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Bolinas Cliffs, Marin County, Lands End - San Francisco County, Ocean Beach & Fort Funston, San Francisco County, Pacifica & El Granada in San Mateo, Alameda South Shore, San Francisco Bay; Santa Cruz, Capitola Beach, Point Mugu, Royal Palms State Beach, Newport Beach, Capistrano & San Clemente beaches & most of south coast: Oceanside & Carlsbad, Sunset Cliffs & Bird Rock; Imperial Beach. See Ref. 49	Coastal erosion is accelerated by storm waves & winds. Wave energy during storms activates seiche & surge conditions. Critical erosion taking place on 163 of the 233 miles in the southern coastal region from Santa Barbara to Mexican border. Of entire state, 5% of shore is critically eroding, 81% noncritical erosion, 14% stable. See Ref. 54	During last 50 years bluffs in central coastal area have lost about 150 feet of shoreline to erosion. See Ref. 56 1944 storm waves attacked eroded beach at Redondo Beach King Harbor & destroyed buildings. Periodic storms have accelerated erosion process & resulted in heavy property & beach losses.	Increasing development of coast contributes to damage potential.	U.S. Army Corps of Engineers State Coastal Commission Regional Coastal Commissions Local Governments Port Governing Bodies	Study coastal erosion problem, plan & construct erosion control structures. See attached note. See attached note. Enact & enforce zoning ordinances & building codes, which may include setback lines &/or structural requirements. See attached note. See attached note.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). California Coastal Act of 1976.
Coastal Flooding	Flooding of coastal rivers & basins. See Ref. 56 North coastal basin - mouth of Eel River at Eureka is subject to recurrent flooding. San Francisco Bay area between Russian River & San Lorenzo River. South coastal basin.	Winter storms where intense rain & winds have caused extensive flooding in coastal cities where the rivers join the ocean. Devastating floods have occurred in 1867, 1907, 1909, 1955, 1964, 1966-67, 1969. 1964-65 one of the worst floods on record. See Ref. 56	Eel River Basin 1964-65 - disastrous flooding; 24 lives lost, railroad track destroyed, entire cattle herds lost. Lumber industry - great losses; 223,000 acres inundated, $184 million in damages. Russian River Basin flood in 1964-65 resulted in 4 deaths. See Ref. 56 1969 floods most damaging on record - in south coastal basin - over 100 lives lost.	Increasing dramatically with rapid population growth & increased property values, particularly with shift from agricultural to urban use.	U.S. Army Corps of Engineers U.S. Geological Survey U.S. Federal Insurance Administration National Weather Service (NOAA) State Office of Emergency Services Local Governments	Study coastal flood problems; plan & construct flood control structures. Prepare flood-prone area maps. Administer NFIA & Flood Disaster Protection Act. Collects & disseminates meteorological information; issues flood warnings. Responsible for disaster planning & on-site assistance. Must provide lands, easements, & rights-of-way for Federally-financed local flood control projects. May adopt flood plain regulations & must do so to qualify for state contribution to costs of local flood control projects. See attached note.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288. Authority includes acquisition of title or easements & power to zone land use in flood plains.

NATURAL HAZARD MANAGEMENT IN THE CALIFORNIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Landslide	Steep canyon topography & instability of rock units all along the coastline result in frequent landslides.	Landslides may be initiated by: earthquakes, unstable rock formations, torrential rainfall & over-development on steep slopes. See Ref. 7	Landslides, rockfalls & rock slumps have resulted in loss of property & life.	Increasing development of coast contributes to damage potential.	U.S. Geological Survey Landslide Hazard Reduction Program	Study landslide problems & provide information about physical characteristics & hazard prone areas.	
					State Division of Mines & Geology	Prepares slope-stability maps.	
					Local Governments	Enact & enforce zoning ordinances & building codes, which may include setback lines &/or structural requirements. See attached note.	

CALIFORNIA COASTAL ACT OF 1976 (AUTHORITIES)

STATE COASTAL COMMISSION

Prepares state coastal zone plan	Planning zone includes coastal watersheds or 5 miles inland from mean high tide line. Completed in 1975
Designates sensitive coastal resource areas	Hazard zones not included
Defines locations inappropriate for energy facilities and reports on suitability of proposed sites for prospective energy facilities to Energy Resources Cons. and Dev. Comm.	Oil and gas development not permitted except where they will not cause or contribute to subsidence unless adequate measures are undertaken to prevent damage from subsidence.
Identifies and recommends special treatment areas to State Board of Forestry	
Recommends appropriate actions to state agencies with responsibilities in the coastal zone	Agencies must adopt Commission's recommendations or report to Governor and Legislature on reasons for non-adoption
Certifies need for regional coastal commissions	
Reviews and approves regulations adopted by regional coastal commissions	
Assumes powers and responsibilities of regional coastal commissions upon their termination	
Considers appeals by local governments of disapprovals by regional commissions of local coastal programs	
May consider appeals of permit actions of regional coastal commissions, local governments, and port governing bodies	Non-conformance with shoreline erosion, or geologic setback requirements is grounds for appeal
Specifies common methodology for preparation of local coastal programs	
Assists local governments in exercising, planning and regulatory powers and responsibilities	
Reviews implementation of local coastal programs and may recommend corrective action to local governments and state legislature	
Prepares local coastal program on request of local government	
Reviews and certifies port master plans	

AUTHORITIES CONT'D.

REGIONAL COASTAL COMMISSION

Prepares recommendations for state coastal zone plan	Completed in 1975
Reviews plans for public works or state university or college land use within coastal zone	
Acts upon permit applications for coastal zone development where a certified local coastal program does not exist	Coastal development defined broadly to include all construction, waste disposal, change in land use intensity, and harvest of timber or kelp. Excludes agriculture
Reviews and may appeal coastal development permits issued by local governments prior to certification of the local coastal program	
Reviews and certifies local coastal programs and amendments thereto	

LOCAL GOVERNMENT

Prepares local coastal program	Must follow common methodology established by State Coastal Commission Must consider uses of more than local importance Must provide adequate protection for sensitive coastal resource areas
Acts upon permit applications for coastal zone development pursuant certified local coastal program	Permitted developments must minimize risks to life and property in geologic flood and fire hazard areas, assure stability and structural integrity, and neither create nor contribute to erosion, geologic instability, nor site destruction, nor require construction of protective devices which would alter natural landforms along bluffs and cliffs Permit requirements may be temporarily waived for certain types of development associated with response to natural disasters Permit zone extends from sea to first public road, or 300 feet from beach or mean high tide line, whichever is greater

AUTHORITIES CONT'D.

PORT GOVERNING BODIES

Prepare master plans consistent with coastal act	
Act upon permit applications for coastal zone development pursuant to certified port master plan	

CONNECTICUT

The Connecticut tidal shoreline is approximately 618 miles in length including peninsulas and islands (U.S. Dept. of Commerce, 1971).

Physically, the Connecticut shoreline has many rocky headlands, coves, and islands created by the southerly movement of glacial ice. These are interspersed with low-lying beaches, coastal wetlands, and low-lying coastal floodplains. These areas are highly susceptible to erosion and storm damage. Hurricanes moving in from the south and northeasters have caused considerable flooding and erosion damage. Coastal flooding from inland storms causing tidal surges in major rivers flowing into Long Island Sound is also a serious problem in Connecticut. The flood of record was on August 19, 1955 when 12.12 inches of precipitation were recorded in Hartford, Connecticut. That flood caused estimated damages of $362 million, of which $15 million occurred along the Connecticut coast (North Atlantic Water Resources Study Coordinating Committee, 1972).

Often overlooked as a potential coastal hazard in Connecticut is earthquake. A major (VIII modified Mercalli intensity) earthquake did occur in 1792 in East Haddam (U.S. Department of Commerce, 1973). Earthquakes continue to occur and the possibility of significant damage from a major earthquake should not be discounted for the Connecticut coastal area.

Table IV-4 shows the nature of the natural hazards in the Connecticut coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The Connecticut Coastal Zone Management office is located within the Department of Environmental Protection as an independent unit.

Connecticut has a number of legal tools with importance for the Coastal Zone Management program. Most important of these is the Tidal Wetlands Program which requires a state permit for disturbance of "areas which border on or lie beneath tidal waters, such as, but not limited to banks, bogs, salt marsh, swamps, meadows, flats, or other low lands subject to tidal action." This broadly inclusive program is potentially supplemented by state encroachment line authority although this has not yet been applied to coastal areas. Both of these laws specify flood hazards as a consideration in the review of permit applications. Nearly all coastal wetlands have now been mapped and recorded for regulatory purposes. These statutes virtually constitute a coastal zone management program for the state's coastal wetlands. Local towns may not adopt coastal wetlands regulations different from those of the state (Lauricella v. Planning and Zoning Board, 1974).

TABLE IV-4

NATURAL HAZARD MANAGEMENT IN THE CONNECTICUT COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	9% of shore is critically *eroding*, 89% noncritical erosion, 2% stable. See Ref. 53	Continual process accelerated by storms.	Undermines structures, depletes important *beaches, damages* protective works.	Increasing development increases *vulnerability.*	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Connecticut Dept. of Environmental Protection	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Responsible for sedimentation & erosion control.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.
Hurricane	Entire coast is vulnerable.	7% probability of hurricane effects, 1% probability of a great hurricane. See Ref. 41 Past events: 1815, 1938, 1944, 1954 (Carol & Edna), 1955 (Diane), 1960 (Donna). 1900–1974 – 6 direct landfalls of hurricanes, including 3 great hurricanes. See Ref. 13	Rain, flooding, storm surge, wind, accelerated erosion. 1938 hurricane – record tidal flooding, 9-11 ft. above normal sea level. See Ref. 13 600 killed in N.Y., Connecticut, Rhode Island, Massachusetts. Also disastrous losses from tidal flooding in 1954 (hurricanes Carol & Edna).	41.1% population increase since last major hurricane. See Ref. 13 Increasing development of coast & inexperience with a major hurricane increases susceptibility.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) U.S. Geological Survey Connecticut Military Dept./Office of Civil Preparedness	Construct storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Prepares flood-prone area maps. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288.
Coastal Flooding	River mouths, wetlands & low-lying coastal areas.	Flooding caused by snow melt, rain, hurricanes, local storms.	Damage to buildings in flood plain, accelerated erosion. Flooding from hurricane Diane. Aug. 1955 – $326 million damage ($15 million along coast), 12.12 in. rain in Hartford, 47 dead. See Ref. 34 Oct. 1955 flood disrupted rehabilitation efforts.	Development of wetlands increases vulnerability to tidal & riverine flooding.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration U.S. Geological Survey Connecticut Dept. of Environmental Protection Connecticut Military Dept./Office of Civil Preparedness	Study coastal erosion problems, plan & construct erosion control structures. Administer NFIA & Flood Disaster Protection Act. Prepare flood-prone area maps. Responsible for flood plain regulations. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Together with USGS has conducted a watershed listing. Also responsible for determining encroachment lines. Responsible under Sec. 201 of PL 93-288.
Earthquake	Entire coastal area.	Minor damage expected. See Ref. 2 69.1 modified Mercalli intensity V earthquakes expected per 100 years. Maximum expected intensity, VIII. See Ref. 61 Major event: 1972 East Haddam intensity VIII. See Ref. 59	Possibility of a large earthquake causing significant social & economic disruption depending on location.	Lack of experience with earthquakes may increase vulnerability.	U.S. Geological Survey Connecticut Geologic & Natural History Survey Connecticut Military Dept./Office of Civil Preparedness	Conducts geological studies in order to monitor & possibly predict seismic activity. Technical studies of geology & soils. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

Delaware is a small state with a disproportionately long coastline. Approximately 548,000 people (U.S. Dept. of Commerce, 1972) live in an area of 1,983 square miles with a 381 mile tidal shoreline (U.S. Dept. of Commerce, 1971). No part of the state is more than eight miles from tidewater. Along the south coast, sandy barrier island beaches and spits protect 120 miles of tidal wetlands. Further north lie 120 miles of tidal wetland, meadow and mudflat shore giving way to thirty-six miles of rock and gravel shore fringed by tidal marsh.

Coastal erosion is the pre-eminent natural hazard. Together with wetlands preservation, they constitute the state's first priority coastal zone management problem. Erosion is caused primarily by winter storms and occasional hurricanes, although navigation and shore protection structures are contributory factors. While twenty-six storms and hurricanes struck Delaware between 1952 and 1973, they did not occur on a regular basis (e.g. 13 between 1970 and 1973) (U.S. Army Corps of Eng., 1971c).

With the exception of a one mile reach south of Indian River Inlet, erosion is critical along the entire ocean and bay coasts. Shoreline recessions vary from three to ten feet per year on the ocean and three to twenty feet per year on the bay. Flooding associated with coastal storms and hurricanes is an infrequent but sometimes serious problem throughout the coastal zone. For example, in March 1962 a winter storm was accompanied by a record tide of 7.9' (3.8' above normal), and waves in excess of twenty feet. Seven deaths occurred and between $16 - 22 million (1962 dollars) worth of damages were sustained by residential, commercial and public facilities, dunes and farm land. More than 10,000 acres of crop land were flooded for five days. Wetlands were damaged and wildlife destroyed by salt water intrusion, debris and sediment. In December, 1974, a northeaster with ten to twelve foot waves and tides four to six feet above mean sea level, caused damages in excess of $3 million along the coast. This storm also compelled evacuation of 800 people (Del. State Planning Office, 1975). Hurricane Belle (1976) resulted in similar evacuation but no heavy damages.

Table IV-5 shows the nature of the natural hazards in the Delaware coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

At the heart of hazards management in Delaware are the: (1) Coastal Zone Act (1971); (2) Wetlands Act (1973); and (3) Beach Preservation Act (1972).

The Coastal Zone Act and the Wetlands Act utilize permit systems to regulate growth in the coastal zone and tidal wetlands. The State Planning Office is responsible for administering the Coastal Zone Management

Program in Delaware. The Department of Natural Resources and Environmental Control (DNREC) issues permits regulating development of wetlands. Actual implementation of land use regulation has been delegated to the county and municipal governments.

The state allows, but does not direct, local governments to adopt and administer zoning ordinances, subdivision control regulations, building codes and official maps. At present only one county has established a comprehensive planning department with zoning and subdivision regulations and requires permits for construction. Two others have passed enabling legislation for planning and zoning.

TABLE IV-5

NATURAL HAZARD MANAGEMENT IN THE DELAWARE COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	12% of shore critically eroding, 14% noncritical erosion, 74% stable or protected. See Ref. 53 Delaware Bay shore, severe erosion problem.	Over the past century, the shore has continuously eroded from 1-25 ft. per year. See Ref. 10	Damages buildings, protection works, beaches, etc. Mar. 1962 storm caused severe erosion, beaches blown inland, buildings destroyed, roads made impassible. See Ref. 56 1962 emergency reconstruction work cost over $2 million to Federal government. See Ref. 56	Increasing with increasing development.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration State Planning Office Delaware Dept. of Natural Resources & Environmental Control Division of Soil & Water Conservation Local Governments	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Administers Delaware Coastal Zone Act (1971). Administers Delaware's Beach Protection Act of 1972. Establish zoning ordinances, building codes, & land use management programs.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding. Permitting agency for activity in the Coastal Zone Coordinates with local governments. Permitting agency for development along the state's beaches. Administers a beach conservation fund created by the act.
Hurricane	Southern coast most vulnerable.	2% probability of hurricane effects, smaller chance of a great hurricane. See Ref. 41 1900-1974 no hurricanes with direct landfalls. Major hurricanes affecting coast: 1944, 1960 (Donna).	Rain, wind, storm surge, & accelerated erosion.	Possibility of a major hurricane striking coast. Inexperience of population may hinder evacuation.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) State Planning Office Local Governments Delaware Dept. of Public Safety/ Division of Emergency Planning & Operations	Construction of storm surge protective structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Administers Delaware Coastal Zone Act (1971). Establish zoning ordinances, building codes, & land use management programs. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Permitting agency for activity in the Coastal Zone Coordinates with local governments. Responsible under Sec. 201 of PL 93-288.
Coastal Flooding	Wetlands, stream mouths & low-lying coastal areas. Southern shore most susceptible to storm caused flooding due to large fetch.	Flooding caused by hurricanes & severe storms.	Damages to structures in the flood plain, damages to wetlands & wildlife. Mar. 1962 storm - much of Bethany Beach & southern Delaware coast flooded by record tide of 7.9 ft (3.8 ft. above normal) & waves in excess of 20 ft. See Ref. 9	Increasing with increasing development.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration U.S. Geological Survey State Planning Office Delaware Dept. of Natural Resources & Environmental Control Delaware River Basin Commission Delaware Dept. of Public Safety/ Division of Emergency Planning & Operations Local Governments	Study coastal flood problems, plan & construct erosion control structures. Administer NFIA & Flood Disaster Protection Program. Prepare flood-prone area maps. Administers Delaware Coastal Zone Act (1971). Administers Beach Protection Act & Wetlands Act (1973). Administers the Delaware River Basin Compact (1961). Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Establish zoning ordinances, building codes, & land use management programs.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Permitting agency for activities in the Coastal Zone. Coordinates with local governments. Permitting agency for wetland development. Classifies land & establishes standards for flood plain use. Responsible under Sec. 201 of PL 93-288.

FLORIDA

Florida has a tidal coastline of 8,426 miles with many divergent physical characteristics (U.S. Dept. of Commerce, 1971). Generally, however, the coastal areas are flat plains less than 100 feet above mean sea level. Almost all of the more populated urban areas are on the coast and are, therefore, vulnerable to damage by the coastal zone's natural hazards. This vulnerability has been increased by the proliferation of "dredge and fill" development in estuarine areas.

The major hazard concern in Florida is hurricanes, and the probability of landfall effects varies greatly around the state. The western part of the panhandle, and some southeastern parts of the peninsula, have a sixteen per cent (16%) annual probability of a hurricane landfall. However, the northeastern part of the state faces only a one per cent (1%) probability of an event (Simpson and Lawrence, 1971).

There are extremely dense population concentrations along some areas of the coast, with inadequate evacuation routes. The average population growth between 1960 and 1970 for the coastal area of the state was seventy-nine per cent (79%), but some areas more than tripled in number of residents. More than three out of four coastal residents have never experienced a major hurricane (Herbert and Taylor, 1975).

A second, though less serious, hazard in Florida is coastal erosion, with five per cent (5%) of the coastline experiencing critical problems (U.S. Army Corps of Eng., 1973a). This is a continual process which is aggravated by hurricane storm surges and winds.

Non-hurricane flooding, although it does exist in the Florida coastal zone, is not considered a major problem.

Table IV-6 shows the nature of the natural hazards in the Florida coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The state has only two regulatory measures dealing with land use and hurricanes. One is a coastal setback line, and the other is a requirement that mobile homes be anchored (which in practice is not strictly enforced). An executive order has been issued directing the State Division of Disaster Preparedness to review and recommend state hazard-zone land use control legislation. The Florida Land and Water Environmental Management Act, which has designated certain keys and swamps along the coastline as areas of Critical State Concern, does not provide for consideration of susceptibility to natural hazards as a criterion for designation. The Bureau of Coastal Zone Planning and Management does technical mapping and planning studies for various coastal areas and serves as a liaison to the regional planning councils.

Municipalities (cities, villages and incorporated towns) and counties have broad zoning and subdivision authorities. The State "Critical Areas Act" authorizes the state to designate areas of critical environmental concern (including flood areas) and to establish standards for local regulations in such areas. Local units must adopt regulations meeting state standards or the state will directly regulate these areas.

Miami authorities, in recognition of the potential catastrophe that failure to evacuate population from low-lying areas would cause, have developed a "vertical evacuation" plan. The concept uses multi-story buildings (which meet certain structural standards) as temporary shelters for evacuees. A law was passed by the state authorizing the governor to commandeer property for such use in an emergency. In addition, south Florida governments have adopted a more stringent building code than the Southern Standard Code. Sanibel, a fast growing island city on the west coast of the peninsula (with one causeway to the mainland) has acted to avert evacuation crises. The Sanibel comprehensive plan takes evacuation capability into account and calls for a cap on population.

The principal piece of state legislation dealing with coastal erosion is the Beach and Shore Preservation Act, administered by the Bureau of Beaches and Shores. The Bureau is charged with establishing coastal construction setback lines in each county. Several variables are taken into account, hurricane storm surge, maximum wave uprush, bathymetry, and erosion trends. Any construction or excavation project seaward of the line must obtain a variance from the Department of Natural Resources (the Bureau's parent agency). Some local governments have their own ordinances for dune protection, but the main adjustment practice (other than the setback law) is structural protection. The Corps of Engineers has a number of beach restoration projects underway or under study.

TABLE IV-6

NATURAL HAZARD MANAGEMENT IN THE FLORIDA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Southern & western coasts most vulnerable. Entire coast exposed.	1-16% probability of hurricane effects, 1-7% probability of a great hurricane in any given year. Miami - 1% probability of 13 ft. storm surge in any given year. See Ref. 41 49 hurricanes, 20 great hurricanes from 1900-1974. Major events: 1916, 1921, 1926, 1935, 1947, 1960 (Donna), 1965 (Betsy). See Ref. 13	Accelerated erosion, storm surge, wind, rain, tornadoes. 1928 hurricane associated flooding; over 2000 drowned, $4 million damage in Florida, Georgia, South Carolina, North Carolina. See Ref. 15 1947 - $5.9 million damage in southern Florida from hurricane flooding. See Ref. 15 1965 (Betsy) - 80 deaths, $1.4 million damage.	78.8% population increase since last major hurricane. See Ref. 13 Inexperience of population, inadequate community preparedness plans & increasing development in coastal areas, especially mobile homes & retired people, increases vulnerability.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) U.S. Geological Survey Florida Division of Disaster Preparedness Florida Dept. of Natural Resources/ Bureau of Coastal Zone Planning & Management Florida Dept. of Natural Resources/ Bureau of Beaches & Shores Florida Division of Vehicle Safety	Construct storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Prepares flood-prone area maps. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Planning studies, technical assistance to local governments, policy recommendations. Determine placement of coastal setback lines; dune protection. Enforce mobile home tie-down regulations.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288. Beach & Shore Preservation Act.
Coastal Erosion	5% critically eroding, 11% noncritical erosion, 84% stable. See Ref. 55 Problem areas receiving attention: Panama City Beach, Treasure Island, Jackson Jacksonville, Miami.	Chronic, accelerated during storms.	Damages beaches, protective works, buildings, roads, etc. Numerous structures destroyed by accelerated erosion during Hurricane Eloise (1975). Many projects constructed to reduce damages from flooding & erosion.	Overreliance on protective works. May encourage development that may later be endangered.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Florida Dept. of Natural Resources/ Bureau of Coastal Zone Planning & Management Florida Dept. of Natural Resources/ Bureau of Beaches & Shores	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Planning studies, technical assistance to local governments, policy recommendations. Determine placement of coastal setback lines; dune protection.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.
Coastal Flooding	Not a dramatic threat in coastal plain. Localized problem areas: Pinellas County, Apalachicola River, the Florida Keys; Some poorly drained areas subject to frequent inundation.	Flooding caused by hurricanes, severe storms.	Several projects constructed to reduce damages from flooding. Generally small threat to life. Some property damage.	Slowly increasing as vulnerable areas are developed.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration U.S. Geological Survey Florida Division of Disaster Preparedness Florida Dept. of Natural Resources/ Bureau of Coastal Zone Planning & Management	Study coastal flood problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Prepares flood-prone area maps. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Planning studies, technical assistance to local governments, policy recommendation.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288.

GEORGIA

The 2,344 mile tidal coastline of Georgia consists of both marshland and sand beaches, the latter found exclusively on barrier islands (U.S. Dept. of Commerce, 1971). For planning purposes, eight counties comprise the landward study area.

The principal hazard in the coastal zone is hurricane with accompanying high wind, storm surge and tornadoes. Although Georgia has escaped substantial damage from hurricanes in recent years, some areas have a seven per cent (7%) annual chance of a landfall (Simpson and Lawrence 1971). Georgians are unaware that Savannah was almost destroyed by an extremely large hurricane in 1893. Between 1960 and 1970 the coastal population of Chatham County (which includes Savannah) quadrupled.

Coastal erosion, the second major natural hazard in Georgia's coastal zone, is a continual process which is exacerbated by hurricane storm surge and winds. Of the approximately twenty-one per cent (21%) of the coast undergoing erosion, three per cent (3%) is termed critical (U.S. Army Corps of Eng., 1973a). Major erosion problems occur on several of the barrier islands, including Tybee Island and Jekyll Island.

Further hazards exist in the Georgia coastal zone and should be taken into account in planning. River and tidal flooding can be major problems when associated with hurricanes, and occasionally occur in the marshlands and low-lying coastal areas. Another, although infrequent, hazard is earthquake. An earthquake of moderate (VII on the modified Mercalli scale) intensity did occur at Milledgeville in 1872 and the possibility of an event of greater magnitude should not be discounted.

Table IV-7 shows the nature of the natural hazards in the Georgia coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

There is little legislation at the state level designed to restrict the use of areas prone to hurricane damage. The principle long term adjustments are local compliance with FIA land use regulations, Corps of Engineers protective structures, and, to some extent, local enactment of erosion and sediment control regulations as required by the Erosion and Sedimentation Act of 1975. This Act requires local governments to pass legislation designed to abate erosion and sedimentation caused by land disturbing activity. Glynn County and the municipality of Savannah Beach have gone further, enacting a beach and dune protection ordinance. Essentially the law utilizes a setback procedure, with permits required for construction seaward of the line.

TABLE IV-7

NATURAL HAZARD MANAGEMENT IN THE GEORGIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	North coast most vulnerable. Entire coast exposed.	1-7% probability of hurricane effects, 1% probability of a great hurricane in any year. See Ref. 41 Savannah - 1% probability of a 12 ft. storm surge, lower heights expected elsewhere. See Ref. 41. 1900-1974 - 4 hurricanes; no major hurricanes. See Ref. 13	Accelerated erosion, rain, wind, storm surge, tornadoes. Savannah devastated in 1893. 1929 flooding associated with a hurricane. $9 million damage in Georgia, North Carolina, South Carolina, Virginia.	No major hurricanes since 1900. Inexperience of population may hinder evacuation. Continued development of hazard area, especially Chatham County, adds to vulnerability.	U.S. Army Corps of Engineers	Construct storm surge protection structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					National Weather Service (NOAA)	Collects & disseminates meteorological information. Issues hurricane warnings.	
					National Hurricane Center (NOAA)	Issues warnings & disseminates hurricane information.	
					U.S. Geological Survey	Prepares flood-prone area maps.	
					Georgia Dept. of Defense/Division of Civil Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Georgia Dept. of Natural Resources	Mapping of flood-prone areas, Federal Insurance Administration coordination.	Mapping done at 1 in. = 1 mile.
					Georgia Office of Planning & Budget/ Division of Planning	General planning coordination with local governments; technical studies.	
					Coastal Area Planning & Development Commission	Planning, advisory & technical assistance to local coastal counties.	
Coastal Erosion	3% of shore critically eroding, 18% noncritical erosion, 79% stable. See Ref. 55 Problem areas: Tybee Island, Jekyll Island, Saint Simon's Island, Sea Island.	Continual process accelerated during storms.	Undermines buildings, transportation routes, utility lines, removes or damages recreational beaches & hurricane protective works. Breaching of barrier islands exposes mainland to storm waves.	Increasing development of coastal areas adds to susceptibility.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					Georgia Dept. of Natural Resources	Technical studies, draft legislation for locals if they fail to do so themselves.	Georgia Erosion & Sedimentation Act of 1975.
					Committee of 3: Commissioner of Natural Resources, Director of Environmental Protection in Dept. of Natural Resources & appointee of Dept. of Natural Resources Board	Reviews all requests for marshland alteration. May issue permit.	Coastal Marshland Protection Act of 1970.
					Georgia Soil & Water Conservation Committee	Works with Georgia Dept. of Natural Resources on Erosion & Sedimentation Act. Drafted model legislation for local governments.	
					Georgia Office of Planning & Budget/ Division of Planning	Planning studies & recommendations to other agencies involved in permitting.	
					Coastal Area Planning & Development Commission	Planning assistance to local governments.	
					Local Governments	Must adopt regulations in compliance with Erosion & Sedimentation Act.	Glynn County & Savannah Beach have enacted dune protection setback lines.

TABLE IV-7 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE GEORGIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	Marshes & low-lying coastal areas.	Flooding caused by hurricanes & severe storms. Not a major hazard below fall line.	Damage to developments in flood plain. Generally minor damage.	Probably not a major problem with existing land use & environmental controls.	U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Act.	See Ref. 31
					U.S. Geological Survey	Prepares flood-prone area maps.	
					Georgia Dept. of Defense/Division of Civil Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Georgia Dept. of Natural Resources	Technical studies; mapping.	
					Office of Planning & Budget/Division of Planning	Planning studies; assistance to local governments.	
Earthquake	Moderate damage expected in north coastal area near South Carolina. No hazard along south coast.	19.9 modified Mercalli maximum intensity V earthquakes expected per 100 years. Maximum intensity expected, X. See Ref. 61	1872 Milledgeville earthquake, intensity VII. Possibility of major earthquake causing significant social & economic disruption, depending *on location*.	Inexperience with earthquakes may lead to a lack of concern as to their potential for damage, increasing *vulnerability*.	U.S. Geological Survey	Conducts geological studies in order to monitor & possibly predict seismic activity.	
					Georgia Dept. of Natural Resources/Earth & Water Division	Technical studies of geology & soils.	
					Georgia Dept. of Defense/Division of Civil Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

HAWAII

Hawaii's has 1,052 miles of tidal shoreline (U.S. Dept. of Commerce, 1971). Most of the population and nearly half the land are within five miles of the ocean.

The state is faced with the threat of numerous natural hazards: coastal flooding, erosion, earthquakes, volcanic eruptions and tsunamis.

Coastal flooding may occur as a result of wind driven waves or of fresh water floods. There are five types of wind-driven waves which cause coastal flooding in the islands; winter swell and Kona are the most hazardous. The winter swell generates waves from fifteen to thirty feet high and is common from October to May. Kona storms occur about once a year and usually result in waves from ten to fifteen feet high. During the past decade, nearly $2 million in damage has been caused by storm waves (U.S. Army Corps of Eng., 1975).

Coastal flooding as a result of inland river flooding is also a hazard within the coastal zone. The severity of fresh water flooding has heightened as development in the upper portions of Hawaii's flood-plains has caused increased rates of erosion. Floods caused twenty-two deaths and $13 million in property damages between 1950 and 1975. Small water sheds and highly permeable volcanic rock make the islands extremely susceptible to flash flooding. Since there is so little surface run-off, stream channels are short, poorly defined, and thus subject to overflow during heavy rains (U.S. Army Corps of Eng., 1975).

Erosion is a continual problem along the Hawaiian coastline. Its effects are, of course, heightened by tsunami and storm surge. Approximately three per cent (3%) of the coastline is said to be critically eroding (U.S. Army Corps of Eng., 1973c).

Earthquakes and volcanic action are frequently tied together within the Hawaiian coastal zone. Most Hawaiian earthquakes are triggered by the movement of magma, although the large ones are generated by tectonic or crustal movements. Thousands of earthquakes usually precede and accompany volcanic eruptions, but few are large enough to be felt. Ten earthquakes exceeding 5.3 (Richter scale) in magnitude have occurred since 1925, six on the Big Island of Hawaii and four from faults on the ocean floor. The Hilo earthquake of 1973 (magnitude 6.2 Richter scale) caused damages of $6 million (Ayre, 1975).

Volcanic eruptions in Hawaii are usually of the shield building type and result in highly fluid lava flows containing little gas. Later stage eruptions contain more gas and are thus more explosive than those of the shield building stage. Lava generally travels between ten and 1000 feet per hour, but flows can exceed five miles per hour and be extremely destructive to coastal areas. Mauna Loa has been active 6.2 per cent of the time, erupting once every 3.7 years on the average over historic time. Kilauea has been active sixty-two per cent (62%) of the time, but most of its activity is confined to the caldera. Lava flows are a threat to Ka'u, South Kona, the City of Hilo, and Puna, where much land is zoned for residential development. The 1960 Kapoho flow caused nearly $5 million in property damages, destroying the village and covering beach lots with lava. Coastal subsidence associated with volcanic activity has also been a problem on Hawaii, particularly at Kalapana (Warrick, 1975).

Another natural hazard associated with seismic activity is tsunami, large sea waves, associated with strong earthquakes and generated by impulsive disturbances. Of the thirty-one tsunamis which have struck the islands during historic time, eight have caused moderate to heavy damage. Historical evidence suggests the northern shores have been most severely affected. The Hawaiian Islands are vulnerable to tsunamis generated in North and South America and also to less frequent, locally generated tsunamis.

Table IV-8 shows the nature of the natural hazards in the Hawaiian coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

Management of the Hawaii coastal zone is shared by several authorities which maintain overlapping jurisdiction within the coastal zone. The counties have authority (special interim controls) under the 1975 Shoreline Protection Act to create special management areas around entire islands, extending inland from the shoreline at least 100 yards, and share control over agricultural areas with the Land Use Commission. The State Department of Land and Natural Resources retains control over conservation land. The State has jurisdiction over the offshore waters, from the shoreline (upward reach of wave action) seaward to the three mile limit, which have been designated for transportation as well as conservation. County authority is also tempered by the 1974 Hawaii Environmental Policy Act, which requires that an environmental impact statement be submitted to the Office of Environmental Quality Control for any proposed development extending from the inland edge of the county setback zone to the offshore waters (300 feet). County setback restrictions extend from a minimum of twenty feet to a maximum of forty feet inland from the shoreline under the 1970 Shoreline Setback Law. Agencies are given standing to intervene or appeal under the State Administrative Procedures Act.

State assistance in the mitigation of natural disasters has encountered much less resistance from county agencies. Historically focused on communications, warning, relief, and education, state efforts also fulfill civil defense objectives (Hawaii Revised Statutes, Chapters 127, 128, 171, 209, 234 & 385). Responsibility for structural measures and land use controls were delegated to the counties under zoning provisions (Hawaii Revised Statutes, Chapter 46). Recent federal requirements for coordination under the Coastal Zone Management and National Flood Insurance programs have widened the potential for both cooperation and conflict in the realm of mitigating natural hazards.

TABLE IV-8

NATURAL HAZARD MANAGEMENT IN THE HAWAII COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	Northwest & north coasts vulnerable to winter swells. Southwest & south coasts exposed to Kona storms. Southwest Kauai, northwest Oahu, east Hawaii are most vulnerable areas. Islands of Kauai, Maui, & windward Oahu have had severe fresh water floods in recent years.	Storm wave flooding: winter swell - 15-30 ft. waves, Oct. - May. Kona storms average 1 per year, 10-15 ft. waves. Southern swell, northeast trades produce smaller waves; hurricanes extremely rare. Flash flooding hazard high.	Damage to property in low-lying areas. Storm waves caused $2 million damage in last decade. Significant threat to lives & property. 1950-1975 22 deaths, $13 million damage from floods.	Increasing with increasing development in flood plains. Development in flood plains & upper basins has increased erosion & severity of floods.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration U.S. Geological Survey National Weather Service (NOAA) Hawaii Civil Defense County Governments Hawaii Dept. of Land & Natural Resources	Study coastal flood problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Program. Prepare flood-prone area maps. Responsible for warning & evacuation. Establish zoning regulations, building codes, setback lines & land use management programs. Issues permits for uses within the State's Conservation Districts.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref: 31
Coastal Erosion	3% of coast is critically eroding, 9% noncritical erosion, 88% stable. Oahu particularly vulnerable. See Ref. 54	Continual process accelerated by storm waves.	Damages structures, roads, protective works, beaches, etc. 1969 storm - 7,000 cubic yds. of sand lost from Haleiwa beach. 9 beach erosion projects completed or studied.	Increasing with increasing development.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Local Governments Hawaii Dept. of Land & Natural Resources, & Hawaii Dept. of Transportation	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Establish zoning ordinances, building codes, & land use management programs. Approves construction of any structure in near-shore waters.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.
Earthquake	Major damage expected - Big Island. Moderate damage expected - Molokai, Lanai, Maui. Minor damage expected - Oahu. See Ref. 2	Largely connected with volcanic activity. 1925-1976, 10 earthquakes exceeded 5.3 Richter. 6 on Big Island, 4 on ocean floor.	May trigger local tsunami. Hilo earthquake, 1973, 6.2 Richter, caused $6 million damage. See Ref. 44	Increasing development increases vulnerability.	U.S. Geological Survey County Governments Hawaii Civil Defense Hawaii Civil Defense	Conducts geologic studies in order to monitor & possibly predict seismic activity. Responsible for warning & evacuation. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Volcano	Most active: Mauna Loa, Kilauea. Cities of Hilo, Puna, Ka'u & South Kona vulnerable.	Fluid lava flows most common. Geologic record shows very infrequent explosive eruptions. Large number of small eruptions on Mauna Loa (averages 1 eruption every 3.7 years). See Ref. 2	Volcanic activity may trigger earthquakes, tsunamis, fires. Kilauea - 1960 Kapoho flow: $5 million property damage. Destroyed village of Kapoho. See Ref. 2	Rapid development increases vulnerability. Puna district has numerous undeveloped land scheduled for subdivisions in hazardous areas.	Hawaii Volcano Observatory (USGS) Hawaii Dept. of Land & Natural Resources Hawaii Civil Defense	Issues volcano warnings & conducts basic volcano research. Issues permits for uses within the State's Conservation Districts. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

TABLE IV-8 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE HAWAII COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Tsunami	Northern shore most vulnerable. Archipelagos in south Pacific diminish wave energy reaching south coast.	Impulsive disturbance in ocean generates a series of long waves which build in height as they approach the shore. 31 tsunamis in historic times. See Ref. 2 8 caused serious damage.	Origin, magnitude, configuration of coast, & extent of coastal development contribute to damage potential. Aleutian tsunami of 1946 - maximum wave height of 55 ft, 173 dead, $25 million damage. Chilean tsunami of 1960 - 35 ft. waves at Hilo, 61 dead, $25 million damage. See Ref. 2	Increasing with increasing development.	U.S. Army Corps of Engineers	In process of identifying *areas of* innundation.	Maps will indicate areas vulnerable to the 100 year tsunami event. Coastal Zone Management regulations will be based on these maps.
					Honolulu Observatory International Tsunami Information Center	Issues tsunami warnings.	
					County Governments & Hawaii Civil Defense	Responsible for warning & evacuation.	
					Hawaii Civil Defense	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					County Governments	Establish zoning regulations, building codes, setback lines, & land use management programs.	
					U.S. Federal Insurance Administration	Administers NFIA & Flood Disaster Protection Act.	See Ref. 31

ILLINOIS

Illinois has a shoreline of only fifty-nine miles on Lake Michigan. Most of the Illinois shoreline in Chicago and Evanston is artificial landfill protected by such measures as revetments, breakwaters and rip=rap. From Wilmette to Winnetka the shoreline is characterized by low bluffs, while from Glencoe to Waukegan there are high bluffs averaging up to eighty feet in height and cut by ravines tributary to the Lake. These bluffs, particularly those in the Village of Lake Bluff, have experienced extreme erosion due to unusually high water levels in Lake Michigan, heavy winter storms, inadequate shore protection, and the weakening of bluff faces from subsurface drainage. Further north, in the Illinois State Beach Park, the bluff is inland and recent dune formations are being rapidly eroded.

Erosion is clearly the major natural hazard within the Illinois coastal zone. Coastal flooding and wave attack presents a second hazard concern.

Table IV-9 shows the nature of the natural hazards in the Illinois coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The Illinois Coastal Zone Management Program is part of the Division of Water Resources within the Illinois Department of Transportation. The Division has jurisdiction over all Illinois waters, has authority to issue permits for structures and fill, to regulate encroachment upon those bodies of water and control the location and design of structures in the flood hazard areas. The Division has developed proposed regulations for the exercise of this authority in the flood-induced erosion hazard area. This authority will be confirmed in comprehensive State coastal legislation to be introduced by the Illinois Coastal Zone Management Program in February, 1977.

Principal jurisdiction landward of the water's edge lies in the thirteen municipalities which share the coastal zone; the state presently has no powers to review municipal decisions on land and water use. The new legislation will create a joint state-local administrative system for the Illinois coastal zone and enable municipalities to effectively control erosion and flooding hazards in accordance with guidelines and criteria contained in the State legislation (Wise, 1976).

TABLE IV-9

NATURAL HAZARD MANAGEMENT IN THE ILLINOIS COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Chicago area - Lake Michigan coast, 59 miles. 16% critical erosion, 84% stable or protected. Lake Forest & Zion coasts most vulnerable.	Accelerated by storms, high water levels. See Ref. 51 Estimated rates: 1 ft. per year at Illinois State Park, 10 ft. per year at Illinois-Wisconsin border. See Ref. 56 Up to 89 feet lost in 11 years at Lake Bluff. See Ref. 70	Damage to beaches, bluffs, buildings, roads, etc. on shore. Damages during 1951-1952 high water, $17.7 million (1970 values). See Ref. 51 17 homes presently endangered by erosion from current high lake levels. Damages for 3 year period 1972-1975 exceed $27 million. See Ref. 70	Extensive use of protective structures limits critically eroding area. Continued high water will endanger more homes.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					International Joint Commission/Great Lakes Levels Board	Control of water level in Great Lakes.	See Ref. 56
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Illinois State Geological Survey	Conducts erosion & sedimentation studies; provides policy recommendations.	
					Local Governments	Establish zoning ordinances, setback lines, building codes, & land use management programs.	
					Illinois Dept. of Transportation/ Division of Water Resources	Coordinating agency for U.S. Coastal Zone Management Act (1972).	
					Northeastern Illinois Planning Commission	Comprehensive regional planning.	
Coastal Flooding	Minor hazard in localized sections of coast. Small streams, urban drainage areas. Extensive flooding in the Illinois Beach State Park & in Lake Calumet vicinity.	Development of flood plain has intensified runoff, resulting in urban flooding. See Ref. 56	Damage to vulnerable property.	Urban flooding study underway. Urban drainage improvements could lessen vulnerability.	U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Act.	See Ref. 31
					U.S. Geological Survey	Prepare flood-prone area maps.	
					International Joint Commission/Great Lakes Levels Board	Control of water levels in Great Lakes.	Undertaken Great Lakes Water Levels Study which incorporates assessment of practicable means of improving flood control throughout Great Lakes.
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Illinois Dept. of Transportation/ Division of Water Resources	Coordinating agency for U.S. Coastal Zone Management Act (1972). Define flood plains within the state.	May issue permits for any construction in the flood plains.
					Local Governments	Establish zoning ordinances, setback lines, building codes, & land use management programs.	
					Illinois Emergency Service & Disaster Agency	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Northeastern Illinois Planning Commission	Comprehensive regional planning.	

INDIANA

The State of Indiana has a relatively small shoreline in comparison with most other coastal states, approximately 45 miles in length.

The Coastal Zone Planning Region is located in the northwest corner of Indiana and reaches from Illinois on the west to Michigan on the east. Lake, Porter, and LaPorte counties have jurisdiction within this zone.

Coastal erosion is clearly the dominant natural hazard in the Indiana coastal zone, and floods pose a rather minor, secondary threat. Of the approximately fifty per cent (50%) of the Indiana shoreline that is eroding, the Corps of Engineers estimates that 28.9% of this erosion is critical, and 21.3% is of a non-critical nature (1971a). Almost all of this erosion is taking place along the eastern half of Indiana's Lake Michigan coast. The western half is heavily protected by man-made structures.

Flooding, although a minor problem along the coast, still presents a matter of some concern, particularly as the flood plains of small streams come under increasing development.

Table IV-10 shows the nature of the natural hazards in the Indiana coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The Indiana State Planning Services Agency (SPSA) was designated as the state agency to receive grants under Sec. 305 of PL 92-583, the Coastal Zone Management Act of 1972, and to administer the state's Coastal Zone Management Program. Its function in this role is mainly one of coordination. The agency was created to assemble and make available information relative to the resources of the state, and to cooperate in the preparation of resource development plans.

The other major agency with responsibility in the coastal zone is the Indiana Department of Natural Resources (DNR) which has responsibility to collect and analyze physical data relative to the coastal zone.

Cities, counties and incorporated towns all have general zoning and subdivision enabling authority. A master plan must be adopted by these governmental units before subdivision regulations are enforced. The state has minimum rules for development in flood ways and broader flood hazard areas, but local governments may enact stricter regulations if they choose.

TABLE IV-10

NATURAL HAZARD MANAGEMENT IN THE INDIANA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Eastern half of Lake Michigan shoreline subject to erosion. Western half is protected by man-made structures. 28.9% of coast critically eroding, 21.3% noncritical erosion, 49.8% stable or protected. See Ref. 51	Continual process accelerated by storms, high water levels.	Damage to buildings, roads, utilities, beaches, etc. 1951-1952 high water levels caused $10 million of erosion damage. See Ref. 51 First cost of protecting critically eroding coast is $10.4 million. See Ref. 54	Development of unprotected areas will necessitate further expenditures to control coastal erosion.	International Joint Commission/Great Lakes Levels Board	Control of water levels in Great Lakes.	See Ref. 56
					U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Local Governments	Study, plan, construct erosion control structures; est. special ordinances.	Indiana Local Plan Legislation.
Coastal Flooding	Not subject to lake flooding. Small streams & urban drainage facilities may flood.	Development of flood plain has intensified runoff, causing severe flooding.	Some damage to vulnerable property.	Chicago urban area flooding study underway. Adequate drainage provisions could reduce urban flood damage.	International Joint Commission/Great Lakes Levels Board	Control of water levels in Great Lakes.	Undertaken Great Lakes Water Levels Study which incorporates assessment of practicable means of improving flood control throughout Great Lakes.
					U.S. Army Corps of Engineers	Study coastal flooding problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Act.	See Ref. 31
					U.S. Geological Survey	Prepare flood-prone area maps.	
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Indiana Dept. of Civil Defense & Office of Emergency Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Indiana Dept. of Natural Resources (Natural Resources Commission)	Establish minimum standards for flood plain management.	
					Local Governments	Must adopt flood plain management ordinances, meeting state minimum standards, for all areas subject to flooding at 100 year recurrence interval. Dept. of Natural Resources approve all local ordinances.	Indiana Local Plan Legislantion.

LOUISIANA

The 7,721 mile Louisiana tidal coastline is characterized mainly by marshlands, although sand beaches do occur on some of the barrier islands (U.S. Dept. of Commerce, 1971).

Hurricanes with accompanying high winds, storm surge, and tornadoes, pose the greatest threat to the coastal area. The annual probability of occurrence along the Louisiana coast varies from six to thirteen percent (6-13%) (Simpson and Lawrence, 1971). The extremely flat relief and low elevation of much of the coast exposes large areas to hurricane flooding. This condition contributed to the 400 deaths and $200 million damage in Cameron Parish in 1957 (U.S. Army Corps of Eng., 1975).

Coastal erosion presents another hazard in the Louisiana coastal zone. Although eighty per cent (80%) of the shore is eroding, only two per cent (2%) is eroding at a critical rate (U.S. Army Corps of Eng., 1973a). The barrier island and delta areas are particularly vulnerable.

Table IV-11 shows the nature of the natural hazards in the Louisiana coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

Aside from local compliance with Federal flood insurance regulations, there is little legislation to control the development of hazardous areas. The principal adjustment is an intricate and extensive system of levees, which is still not complete. Some cities are literally encircled by levees; some are designed to keep bayous or rivers in their banks, and others to keep tidal and hurricane flood waters out. This situation creates a drainage problem, however, and pumps have to be used to expel water from within the levee system. In recognition of tremendous risk faced by New Orleans, the New Orleans District of the Board of Levee Commissioners devised a vertical evacuation plan similar to that of Miami. New Orleans has not been flooded by the Mississippi since 1840. As with any structural adjustment, however, the catastrophe potential is high. In 1973, when the river rose exceptionally high, the levees had to be reinforced with sandbags.

Erosion is combatted almost exclusively by structural measures, with local, state and Federal agencies involved in construction and operation.

TABLE IV-11

NATURAL HAZARD MANAGEMENT IN THE LOUISIANA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	New Orleans & Southern Delta most vulnerable; whole coast is exposed.	6-13% probability of hurricane effects in any year, 1-4% probability of a great hurricane. See Ref. 41 1% probability of 15 ft. storm surge near Lake Charles, 1% probability of 14 ft. storm surge near New Orleans. See Ref. 41 1900-1974 - 19 hurricanes, 10 great hurricanes. See Ref. 13 Major events: 1957 (Audrey), 1964 (Hilda), 1965 (Betsy), 1969 (Camille), 1974 (Carmen).	Rain, wind, storm surge, tornadoes, accelerated erosion. Major events: 1965 (Betsy) - 89 deaths, $1-2 billion damage in southern states. See Ref. 56 1957 (Audrey) - 400 dead, $200 million damage in Cameron Parish. Millions of dollars spent on structural adjustments to flooding, hurricane, erosion. See Ref. 56	17.3% population increase since last great hurricane. See Ref. 13 30% of population has never experienced a major hurricane. Increasing development of hazard area adds to vulnerability potential for extreme losses in New Orleans.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) Louisiana Dept. of Civil Defense & Emergency Preparedness Louisiana State Planning Office	Construction of storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. *Administers Coastal* Resources Program	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288.
Coastal Flooding	Rivers, bayous, & low-lying coastal areas.	Floods caused by hurricanes & severe storms. Overbank flows rare due to extensive levee system. New Orleans last flooded by Mississippi River in 1840. High water in backwater areas causes considerable damage. Levees on Mississippi haven't overtopped since 1927. Levees compound drainage problems.	Extensive levee system keeps average losses low. 1927 flood on Mississippi River, 18 million acres flooded in 6 states. See Ref. 56	Continued development of low-lying land increases susceptibility, although structural adjustments have reduced average losses. Catastrophe potential increasing. New Orleans levees had to be sand bagged in 1973.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Municipal Governments & Parishes U.S. Geological Survey Louisiana Dept. of Civil Defense & Emergency Preparedness	Study coastal flooding problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Adopt flood plain zoning, building codes, & land use regulations. Prepare & disseminate flood-prone area maps. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	2% critically eroding, 80% noncritical erosion, 18% stable. See Ref. 54 Beaches & delta are particularly susceptible. See Ref. 59	Chronic, accelerated by storms.	Damages beaches, protective works, buildings, roads, etc. Contributes to sedimentation problems.	Rapid increase in vulnerability, mainly on Lake Ponchatrain.	U.S. Army Corps of Engineers U.S. Soil Conservation Service Louisiana Dept. of Public Works U.S. Federal Insurance Administration	Study coastal erosion problems, plan & construct erosion control structures. Participates in erosion control projects. Construction of protective structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.

MAINE

Maine's deeply indented and island-studded coastline is estimated to be 3,498 miles in length (U.S. Dept. of Commerce, 1971). Much of this shoreline is metamorphic rock and is largely invulnerable to erosion. The threat of erosion is serious, however, along the heavily developed beach and marsh shorelines between Portland and the New Hampshire line. Likewise, ocean front communities such as Popham Beach are vulnerable to flooding during occasional hurricanes. Flooding may also occur along the upper reaches of numerous narrow inlets due to tidal surges. Bangor experienced severe and unexpected flooding in the winter of 1976 from this source.

A final hazard to be considered in the Maine coastal area is that of earthquake. Although the probability of occurrence is low, a major (VII modified Mercalli intensity) quake was reported in southeast Maine in 1904. The possibility of recurrence should not be overlooked.

Table IV-12 shows the nature of the natural hazards in the Maine coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

Maine has several laws and programs upon which it intends to base its coastal zone management effort. The Site Location Act requires a state permit for construction of public or private facilities on sites of more than twenty acres or having a floor area of more than 60,000 square feet. The Shorelands Zoning Act further protects all lands within 250 feet of any coastal or inland shoreline through mandatory or state imposed zoning. (Some coastal communities have no zoning except for their shorelands.) A third layer of review is provided under the Coastal Wetlands Act for all activities which would "remove, fill, dredge, or alter any such area".

TABLE IV-12

NATURAL HAZARD MANAGEMENT IN THE MAINE COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	South coastal area high susceptibility to erosion-triggered land-slides. See Ref. 62 1% critical, 99% noncritical, 0% stable. Ref. 53 Developed beaches & shorelines between Portland & New Hampshire border particularly vulnerable.	Continual process accelerated by storms.	Undercuts structures, removes beaches, contributes to sedimentation in harbors. $27.5 million estimated cost to protect 20 miles of coast. See Ref. 56	Low catastrophe potential. Damages increasing with development of coastal areas.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					Maine Land Use Regulatory Commission/ Dept. of Environmental Protection	Inventory critical erosion areas, designate hazard zones, supervise local zoning ordinances.	Described as any area within 250 ft. of the normal high water mark of any pond, river, or salt water body.
					Maine Office of State Planning	Responsible for Coastal Zone Management Program administration.	
					Local Governments	Establish zoning ordinances for critical areas.	Must meet standards of Land Use Regulatory Commission.
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
Hurricane	Entire coast is vulnerable to some extent. Mid latidude cyclones & northeasters are related hazards.	4-6% probability of hurricane effects. See Ref. 41 1900-1974 - 4 direct land-falls of minor hurricanes. See Ref. 13 Major storms: 1815, 1938, 1944, 1953, 1954 (Edna), 1959, 1960 (Donna), 1969, 1976 (Belle).	Accelerated erosion, winds, rain, storm surge. Nov. 1945 - Portland coastal flood caused by a northeaster. 2 ft. above annual spring tide, 8.7 ft. above mean sea level. Most damage in south coastal area. Rest of coast moderate, scattered damages.	Development of coast increases susceptibility; no experience with a large magnitude hurricane.	National Weather Service (NOAA)	Collects & disseminates meteor-ological information. Issues hurricane warnings.	
					National Hurricane Center (NOAA)	Issues warnings, disseminates hurricane information.	
					U.S. Army Corps of Engineers	Construction of storm surge protection structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					Maine Bureau of Civil Emergency Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Maine Office of State Planning	Responsible for Coastal Zone Management Program administration.	
Coastal Flooding	Coastal rivers, low-lying areas, upper reaches of narrow inlets. Ocean front communities vulnerable.	Caused by rapid snow melt, ice jams, hurricanes, northeasters & severe storms. 13 floods in 75 years. See Ref. 15 Tidal flooding - average of 5 floods, 1.5 ft. or greater than annual spring tide, per 40 years.	Adds to coastal erosion, damages structures in flood plains. Androscoggin flood of record: 1936 - 4 dead, 1,500 families homeless, heavy damages. See Ref. 56 Bangor - severe floods, winter of 1976 from tidal surges.	Increasing with increasing development.	U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Geological Survey	Prepare flood-prone area maps.	
					Maine Land Use Regulatory Commission/ Dept. of Environmental Protection	Inventory critical flood areas, designate hazard zones, supervise local zoning efforts.	
					Maine Office of State Planning	Responsible for Coastal Zone Management Program administration.	
					Local Governments	Establish zoning ordinances, for hazard areas, land use controls & construction codes.	Must comply with Land Use Regulatory Commission standards.
					U.S. Federal Insurance Administration	Administers NFIA & Flood Disaster Protection Act.	See Ref. 31
					Maine Bureau of Civil Emergency Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Earthquake	North coast vulnerable to minor damage. South coast - no hazard. See Ref. 2	Expected 33.5 modified Mercalli intensity V earth-quakes per 100 years. Maximum expected intensity, VIII. See Ref. 61 Major events: 1904, south-east Maine, intensity VII. See Ref. 59	Low probability event could cause severe damage depending on location. Little experience with major earthquakes.	Increasing with increasing devel-opment of coastal areas.	Maine Dept. of Conservation Bureau of Geology	Geologic inventory & mapping.	
					Maine Office of State Planning	Responsible for Coastal Zone Management Program administration.	
					Maine Bureau of Civil Emergency Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

MARYLAND

The Maryland coastal zone possesses two components: (1) a 31 mile strip of sandy barrier beaches and islands backed by 203 miles of lagoon and wetland shore, fringing the Atlantic ocean; and (2) approximately 3,190 miles of banks and bluffs ranging up to 100 feet high along Chesapeake Bay and its tidal tributaries (U.S. Dept. of Commerce, 1971). Much of the lower eastern bay shore is predominantly marshy.

Coastal erosion and tidal flooding are serious natural hazards in Maryland. Erosion is often accompanied by small scale landslides and occasional mudflows. The state's oceanic shore also suffers infrequent hurricane damage. In any given year there is a two per cent (2%) chance that hurricanes will directly impact the coast (Simpson and Lawrence, 1971). Associated storm surges and riverine flooding may affect bayshore communities (U.S.G.S. & NOAA, 1975). Parts of Maryland's western bayshore may experience moderate levels of seismic activity (up to modified Mercalli scale VII) but detailed information on seismic risk is lacking.

Over 25,000 acres of land were lost through erosion between 1845-1942 (Singewald and Slaughter, 1949). Critical erosion affects the entire oceanfront. The problem is worst in the northernmost five miles of Assateague Island where losses of thirty-five feet per year occurred during the 1934-42 period. Most erosion is due to winter storms although occasional hurricanes can inflict serious damages.

The main causes of bayshore erosion include storm wave run up, erodible cliffs and a general long term widening and shallowing of Chesapeake Bay. Heaviest erosion losses have been sustained along the lower eastern Chesapeake shore. Here thirty-eight per cent (38%) of the shoreline is affected by high rates of erosion (Maryland Dept. of Natural Resources, Series A). Twelve per cent (12%) of the northeastern shore suffers similar problems, whereas only eight per cent (8%) of the western bayshore is thus affected. Dorchester County accounts for about one quarter (24.9%) of all mainland erosion losses and approximately thirty-two per cent (32%) of all island losses (Maryland DNR, Series A).

Tidal flooding of wetlands and agricultural land is a major problem on the southeastern Bay shore (Somerset and Dorchester counties). Islands surrounding Tangier Sound are particularly affected although most occupants have constructed buildings in comparatively secure areas. Riverine flooding of urban areas is more serious on the western shore (e.g. Baltimore). Elsewhere recreational homes and agricultural lands are the principal victims (Md. Dept. of State Planning, 1974 & 1975).

More than $1 million (1962 dollars) worth of public and private property damage was inflicted on the Atlantic ocean front by the Easter 1962 storm and required costly reconstruction in the Ocean City beach area. Tropical storm Agnes (1972) killed seventeen people and caused more than

$110 million worth of damage on land plus $134 million damage to fishing and related industries on Chesapeake Bay. Damages from the 1962 storm were partly attributable to flooding and partly to erosion, whereas Agnes primarily generated riverine flood related losses (Maryland, State of, 1975).

Table IV-13 shows the nature of the natural hazards in the Maryland coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

Maryland possesses a battery of legislation for coping with natural hazards in the coastal zone. Primary emphasis is placed upon the Wetlands Law (1972); State Land Use Act (1974); Sediment Control Act (1970); Beach Erosion Control District Act (1975); and a group of supporting laws regulating construction within the 100 year floodplain (e.g. HB 708(1976), and Art. NR #8-803 Maryland Code).

Through the State Wetlands Acts of 1970, the state can directly control developments on the tidal wetlands and exerts indirect control over non-tidal wetlands through its waterway construction obstruction permit system and comments on the expanded Section 404 Corps of Engineers Permits System (Maryland Dept. of Natural Resources, 1976).

In Maryland, counties, rather than municipal governments, possess the most effective land use management powers. All seventeen coastal counties have adopted, or are in the process of adopting comprehensive master plans and zoning codes, and all but one possess subdivision regulations and building codes. Eight of seventeen coastal counties have flood hazard controls, six have incorporated these into zoning ordinances, five into subdivision regulations, three into grading and sediment ordinances, and two into other plans (Md. Dept. of State Planning, 1974).

TABLE IV-13

NATURAL HAZARD MANAGEMENT IN THE MARYLAND COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Entire ocean-front subject to serious erosion. Heaviest bayshore erosion along lower eastern coast. 9% of coast critically eroding, 77% noncritical erosion, 14% stable. See Ref. 53	Continual process accelerated by storms. High rates of erosion & sedimentation: 1845-1942 estimated 25,000 acres of land eroded away. See Ref. 42	Damages buildings, roads, protective works, beaches, bluffs. Protection works are costly & not guaranteed to work. Sedimentation necessitates continual harbor clearance.	Coastal development increases susceptibility.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					Maryland Dept. of State Planning	Administers Critical Areas Designation Act (1974).	Act establishes a procedure whereby local governments & regional agencies may recommend areas within their jurisdiction as areas of critical concern.
					Maryland Dept. of Natural Resources	Administers Maryland's Shore Erosion Control Act.	Development of structural projects; administers the State Shore Erosion Control Construction Loan Fund.
						Administers Maryland's Coastal Zone Management Program.	
					Local Governments	Establish zoning regulations, building codes, & land use management programs.	
Coastal Flooding	Low-lying coastal areas, wetlands & estuaries.	Flooding caused by hurricanes, severe storms. Flooding common in Feb. & Apr. (snow melt), & summer & fall (hurricanes). Major floods 8 times in 50 years. See Ref. 56	Flood damage to structures in flood plain. 1936 flood - $12.6 million damage (1936 values). See Ref. 56	Increasing development will increase vulnerability.	U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood control structures.	See Ref. 54
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Act.	See Ref. 2
					U.S. Geological Survey	Prepares flood-prone area maps.	
					Maryland Dept. of State Planning	Administers Critical Areas Designation Act (1974).	Act establishes a procedure whereby local governments & regional agencies may recommend areas within their jurisdiction as areas of critical concern.
					Water Resources Administration	Administers Tidal Wetlands Act (1970). Controls all development in tidal wetlands.	
					Maryland Dept. of Natural Resources	Administers Maryland's Coastal Zone Management Program.	
					Maryland Civil Defense & Emergency Planning Agency	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Local Governments	Establish zoning regulations, building codes, & land use management programs.	

TABLE IV-13 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE MARYLAND COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Southern part of Chesapeake Bay; Atlantic coast most vulnerable	2% probability of hurricane effects. See Ref. 41 1900-1974 no major hurricane landfalls. See Ref. 13 Major hurricanes affecting coast: 1944, 1960 (Donna). 1972 - Tropical storm Agnes: 17 killed & more than $244 million damage. See Ref. 21	Rain, storm surge, tornadoes, winds & accelerated erosion.	Inexperience of population may hinder evacuation. Increasing development of coast increases vulnerability. Evacuation problems particularly serious in Ocean City vacation area--potential disaster area.	U.S. Army Corps of Engineers	Construct storm surge protection structures.	See Ref. 54
					National Weather Service (NOAA)	Collects & disseminates meteorological information. Issues hurricane warnings.	
					National Hurricane Center (NOAA)	Issues warnings, disseminates hurricane information.	
					Maryland Civil Defense & Emergency Planning Agency	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Maryland Dept. of State Planning	Administers Critical Areas Designation Act (1974).	Act establishes a procedure whereby local governments & regional agencies may recommend areas within their jurisdiction as areas of critical concern.
					Maryland Dept. of Natural Resources	Administers Maryland's Coastal Zone Management Program.	
Earthquake	Moderate risk in parts of Maryland's western bayshore.	Maximum expected event VII modified Mercalli. See Ref. 14	Little experience with earthquakes.	Low probability event could cause moderate damage. Detailed information on seismic risk is lacking.	U.S. Geological Survey	Conducts geologic studies in order to monitor & possibly predict seismic activity.	
					Maryland Geological Survey	Technical studies of geology & soils.	
					Maryland Civil Defense & Emergency Planning Agency	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

MASSACHUSETTS

The Massachusetts tidal shoreline is approximately 1519 miles in length, including islands (U.S. Dept. of Commerce, 1971). The shoreline is characterized by extensive beaches on Cape Cod and the islands of Nantucket and Martha's Vineyard. The shoreline between Cape Cod and Boston is composed of low level coastal estuaries and beaches subject to considerable erosion hazard, particularly in the vicinity of Scituate, Marshfield and Duxbury. North of Boston the shore is rocky with many islands and scenic headlands extending to the eastern-most point, Cape Ann. Between Cape Ann and the New Hampshire line there are additional beaches and estuaries along the Ipswich-Newburyport and Salisbury shorelines which are also subject to severe coastal erosion.

Coastal storm surge flooding presents another hazard to the Massachusetts shoreline. Serious flood damage was incurred in the hurricanes of 1938, 1944, twice in 1954, in 1955 and 1960 (U.S. Army Corps of Eng., 1971c).

The possibility of a damaging earthquake occurring in the Massachusetts coastal area is another hazard which must be taken into account. Major (VIII modified Mercalli intensity) quakes occurred at Newbury in 1727 and at Cape Ann in 1755 (U.S. Dept. of Commerce, 1973). The possible recurrence of these events should not be overlooked.

Table IV-14 shows the nature of the natural hazards in the Massachusetts coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The Coastal Zone Management program in Massachusetts is administered by a newly established division of the Executive Office of Environmental Affairs. It is only a planning and advisory body, quite distinct from the line regulatory agencies. However, several regulatory tools do exist for management of coastal hazards. These tools fall primarily under the administrative responsibility of the Department of Environmental Quality Engineering (formerly Department of Natural Resources). The Massachusetts Zoning Enabling Act, as revised in 1975, (Mass. Gen. Law, Ch. 40A) forms the cornerstone of hazards management in the Massachusetts coastal zone by including safety from flood as a purpose of zoning.

Under the "Hatch Act" (Mass. G.L., Ch. 131, sec. 40) local conservation commissions are authorized to regulate (but not prohibit) encroachments upon inland and coastal wetlands, broadly defined to include beaches, dunes, and a zone bounded by a line 100 feet inland from the 100 year flood boundary. Local determinations are reviewable by the Mass. Department of Environmental Quality Engineering. A parallel tool lies in the power of the state to impose "restrictive orders" upon inland and coastal wetlands directly (Mass. G.L., Ch. 131, sec. 40A and Ch. 130, sec. 105). This program lies within the Department of Environmental

Management. (Recent reorganization of the Massachusetts environmental bureaucracy has thus delegated the key programs relating to coastal wetlands management to two agencies.)

TABLE IV-14

NATURAL HAZARD MANAGEMENT IN THE MASSACHUSETTS COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	11% critical erosion, 86% noncritical erosion, 3% stable. See Ref. 53 Outer beaches of Cape Cod & islands particularly vulnerable.	Continual process accelerated by storms.	Erodes recreational beaches, damages buildings, roads, protection works, etc. Estimated cost of $210 million to protect 136 miles of shoreline. See Ref. 56	Increasing with increasing coastal development	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					Massachusetts Dept. of Environmental Quality Engineering	Responsible for improvement & safety of waterways, & protection of tidal waters, shores & foreshores.	Reviews notices of intent submitted by individuals planning any activity that might alter the coastline. Waterways Program.
					Massachusetts Dept. of Environmental Management	Responsible for regulating, restricting, or prohibiting alteration or pollution of coastal wetlands.	Coastal Wetlands Restriction Program.
					Massachusetts Dept. of Transportation	Authorized to prohibit any removal of any stone, gravel, etc. from beaches, shores, bluffs, headlands, islands or bars.	
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
Coastal Flooding	Merrimack River-major river with mouth on coast. Many shorter streams in coastal area.	Floods caused by local storms, hurricanes, northeasters & snow melt. Major flooding in 1936, 1955, & 1968.	Damage to development in flood plain. Numerous protection projects have been constructed to control flooding.	Increasing development in flood plains causes a significant increase in vulnerability.	Massachusetts Dept. of Environmental Quality Engineering	Responsible for improvement & safety of waterways, & protection of tidal waters, shores & foreshores.	Reviews notices of intent submitted by individuals planning any activity that might alter the coastline. Waterways Program.
					Massachusetts Dept. of Environmental Management	Responsible for regulating, restricting, or prohibiting alteration or pollution of coastal wetlands.	Coastal Wetlands Restriction Program.
					U.S. Army Corps of Engineers	Study coastal flooding problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Act.	See Ref. 31
					New England River Basins Commission	Assists & coordinates New England states in dealing with Coastal Zone Management problems of interstate or regional concern.	
					Massachusetts Civil Defense Agency & Office of Emergency Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Hurricane	North coast most vulnerable to northeaster. South coast more vulnerable to hurricanes.	On south coast: 6% probability of hurricane effects, 1% probability of a great hurricane. See Ref. 41 1900-1974 - 5 hurricanes, including 2 great hurricanes with direct landfalls in Massachusetts. See Ref. 13 Major events: 1938, 1944, 1954 (Carol & Edna), 1955 (Diane), 1960 (Donna), 1976 (Belle).	Rain, wind, accelerated erosion, storm surge. Buzzards Bay, Sept. 1938 - heavy rainfall, high tides & hurricane winds combined to produce flooding over 14 ft. above mean sea level; 187 dead. Outer islands: south Cape Cod, Sept. 1944 - flood levels 11 ft. above mean sea level. See Ref. 56	67.7% population increase since last major hurricane. See Ref. 13 Belle (1976) weakened before landfall. Inexperience with a major hurricane may hinder evacuation. Vulnerability increasing with development of coastal areas.	U.S. Army Corps of Engineers	Construct storm surge protection structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					National Weather Service (NOAA)	Collects & disseminates meteorological information. Issues hurricane warnings.	
					National Hurricane Center (NOAA)	Issues warnings, disseminates hurricane information.	
					U.S. Geological Survey	Prepare flood-prone area maps.	
					Massachusetts Civil Defense Agency & Office of Emergency Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

TABLE IV-14 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE MASSACHUSETTS COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Earthquake	Major damage expected along north coast. Moderate damage at Cape Cod, Buzzards Bay. See Ref. 2	North coast - expected 117.6 modified Mercalli intensity V earthquakes per 100 years. Maximum intensity expected, IX. South coast - expected 69.1 modified Mercalli intensity V earthquakes per 100 years. Maximum expected intensity, VIII. See Ref. 61 Major events: 1727 Newbury, intensity VIII; 1755 Cape Ann, intensity VIII. See Ref. 59	Little experience with earthquakes, possibility of a great earthquake in Boston area. Side effects: fire, large-scale social & economic disruption.	Increasing with increased development in Boston area. Seismic risk areas unknown.	U.S. Geological Survey	Conducts geological studies in order to monitor & possibly predict seismic activity.	
					Massachusetts Dept. of Transportation/State Geologist	Technical studies of geology & soils.	
					Massachusetts Civil Defense Agency & Office of Emergency Preparedness	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Cities & Towns	Compulsory building code, includes seismic considerations.	Massachusetts Building Code 23B: 16 et. seq. (effective January 1, 1975).

MICHIGAN

Michigan's coastal zone is approximately 3,282 miles in length including islands (Ervin, 1976). Physical characteristics of the shoreline are diverse, ranging from the marshes of Saginaw Bay and Lake Erie, to the rock coasts of Lake Superior, to the sand dunes and beaches along Lake Michigan's eastern shore (Mich. Dept. of Natural Resources, 1973). Uses of the shoreline are similarly diverse and vary from heavy recreational use of beaches near metropolitan areas, to urban, commercial and industrial developments, to the sparsely developed, remote Upper Peninsula.

Coastal flooding and coastal erosion represent continuing problems in Michigan's coastal zone. Coastal flooding is deemed a serious problem, having caused millions of dollars in property losses and land damages. At present, coastal flooding associated with high lake levels affects over 45,000 acres of land area, encompassing over 300 miles of Michigan shoreline and involving approximately thirty-three coastal counties (Mich. Dept. of Natural Resources, 1973a).

Four times during the past decade coastal flooding has resulted from a seiche, an oscillation of the lake's surface set in motion by a passing storm system. Although coastal erosion is a continual process, several periods of accelerated erosion have caused extensive damage to shoreline property. The most severe coastal erosion has occurred during periods of high lake levels. Levels of the Michigan and Huron have been sufficiently high in thirty-four of the years since 1900 to cause accelerated erosion (Mich. DNR, 1973). Periods during the late 1920's, mid 40's, early 50's and early 70's have been particularly damaging. The combined flood and erosion damages for Michigan's shorelands during the 1951-52 period, the most recent period for which we have damage surveys, represented twenty-nine per cent (29%) of the total flood and erosion damages for the total Great Lakes shoreline and amounted to $17.4 million.

Table IV-15 shows the nature of the natural hazards in the Michigan coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures. The 1970 Shorelands Protection and Management Act, as subsequently amended, is the cornerstone of natural hazards management under the Michigan Shoreland Management Program. This act assigns principal responsibility to the Michigan Department of Natural Resources, but also relies upon local government exercise of zoning restrictions and other land use controls. Michigan has moved vigorously to inventory hazard areas and to otherwise implement the Shorelands Act, but the period of experience with the management phase is still too short to permit evaluation.

TABLE IV-15

NATURAL HAZARD MANAGEMENT IN THE MICHIGAN COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	365 miles along L. Superior are erodible. 80 miles considered high risk. 2/3 of upper Penn. shore of L. Huron is erodible; 109 miles is high risk. 547 miles or 66% of L. Michigan shoreline is erodible - 336 miles is high risk. See Ref. 27 Of entire Michigan coast, 5% critically eroding, 33% noncritical erosion, 62% stable. See Ref. 51	Damages related to coastal erosion are greatly increased during periods of high lake levels as occurred during the late 1920's, mid-1940's, early 1950's, & early 1970's. Erosion may also become accelerated as a result of winter storms & seiche occurrances during such high water periods.	Little loss of life but extensive damages to recreational beaches & private property due to coastal erosion. In 1951, 1952, coastal erosion alone was responsible for nearly $12 million in property damage. See Refs. 23 & 25 Nov. 14, 1972 winter storm in Saginaw Bay resulted in serious coastal erosion. See Ref. 25	Increasing with increased development of shoreline area & increasing property values.	International Joint Commission/Great Lakes Levels Board	Control of water levels in the Great Lakes.	See Ref. 56 (Minnesota)
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					U.S. Army Corps of Engineers	Study Coastal erosion problems, plan and construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					Michigan Dept. of Natural Resources	Inventory critical erosion areas, designate high risk erosion areas, approve local zoning ordinances, administer permit program where approved local zoning ordinance lacking. Applies only to undeveloped, unplatted property, although local ordinance may be more comprehensive.	High risk erosion areas are those subject to recession rate of 1 foot or more per year. Local zoning ord ordinance for high risk erosion areas must require (a) 30 year setback or (b) moveable structures or (c) structural protection.
					Michigan Dept. of State Police	Prepare Emergency Preparedness Plan, coordinate disaster response.	See Ref. 26
					Regional Planning Agencies	Assemble plans for coastal zone management under contract to the Dept. of Natural Resources.	
					Local Governments	Enact & enforce shoreland or other zoning ordinances. Establish land use controls, construction codes, etc.	Must meet DNR standards described a above. Subject to standards established in State Emergency Preparedness Plan.
Coastal Flooding	Coastal flooding is considered a severe hazard in many parts of the state; representing about 200 miles of mainland shoreline & 100 miles of island shoreline. See map p. 11, Ref. 24 Low-lying Lake Erie shoreline is subject to severe flooding. See Ref. 23 All of Michigan's portion of Lake St. Clair is subject to severe flooding.	Periods of extreme high water are a chronic problem and have occurred during the late 1920's, mid-1940's, early 1950's, and early 1970's. Periods of high water have been accompanied by winter storms, and on 4 occasions during the 1960's by seiche, at which time severe flooding has occurred.	1951-1952 floods caused $.5 million in public losses & almost $5 million in private property losses. June 30, 1968 seiche caused waves 5-6 ft. above normal & resulted in damage to 2 coastal communities. See Ref. 68 Nov. 14, 1972 - Saginaw Bay winter storm resulted in waves 8-12 ft. above normal, causing $7 million damage, the evacuation of 15,000 people; roads, break-waters & retaining walls washed out. See Ref. 25	Increasing in degree with each new major flood due to increased shoreline development & increasing property values.	International Joint Commission/Great Lakes Levels Board	Control of water levels in the Great Lakes.	See Ref. 56 (Minnesota)
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					U.S. Army Corps of Engineers	Study flood problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Delineate flood hazard areas, administer flood insurance program.	See Ref. 31
					Michigan Dept. of Natural Resources	Inventory flood hazard areas, designate high risk flood areas, approve local zoning ordinances, administer permit program where approved local zoning ordinances lacking. Applies only to undeveloped, unplatted property, although local ordinance may be more comprehensive.	Flood risk areas are those subject to flooding by 100 year flood. Local zoning ordinances for flood risk areas must (a) prohibit construction or (b) require elevation or (c) require flood-proofing. See Ref. 14
					Michigan Dept. of State Police	Prepare Emergency Preparedness Plan, coordinate disaster response.	See Ref. 26
					Regional Planning Agencies	Assemble plans for coastal zone management under contract to the Dept. of Natural Resources.	
					Local Governments	Identify flood plains; establish standards for new construction on flood plain lands, enact & enforce shoreland or other zoning ordinances containing other provisions. Establish land use controls, construction codes, evacuation & shelter procedures, etc.	Must meet DNR minimum standards described above. Subject to standards established in State Emergency Preparedness Plan.

MINNESOTA

Minnesota's coastal zone consists of 206 miles of Lake Superior shoreline north and east of the City of Duluth. Most of it is steep, rocky and sparsely populated. Coastal flooding occurs, but poses only minor problems, except in the Duluth area, where more gentle topography and more extensive development create a greater potential for damage. Coastal erosion (mostly loss of beach areas) occurs along the entire coast, but is, in terms of short range effect, considered a critical problem on only two per cent (2%) of the shoreline located in the Duluth area. Both coastal flooding and erosion are associated with periods of high water levels and storm action in Lake Superior. During the high water level period of 1951-52, very rough estimates of flood damages and erosion damages sustained (primarily in Duluth) represent ten per cent (10%) and two per cent (2%), respectively, of total flood damages and erosion damages along the entire U.S. Great Lakes shoreline during that period (U.S. Army Corps of Eng., 1971a).

Table IV-16 shows the nature of the natural hazards in the Minnesota coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures. The 1969 Flood Plain Management Act and the 1973 Shoreland Development Act are the cornerstones of natural hazard management under existing Minnesota law, but additional legislation will be proposed as a part of the Coastal Zone Management program now being developed. Due to the recency of the shoreland management legislation and the fact that no floodplains have yet been designated in the coastal zone, there is little experience to show how these coping measures will work. The Department of Natural Resources and Arrowhead Regional Development Commission have recently completed a Shoreland Damage Survey to determine recession rates in order to prepare regulations for land use in the coastal region.

TABLE IV-16, NATURAL HAZARD MANAGEMENT IN THE MINNESOTA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	Duluth area.	Caused by storms occurring during periods of high water levels in Lake Superior (2 ft. above normal water level), especially during late fall, early winter & early spring. See Ref. 56	Little hazard to life; rough estimate reported property damage of $1,119,000 experienced in 1951-1952 high water period. See Ref. 56	Increasing slowly; aggravated by maintenance of higher lake stages superimposed on high wave run-up.	International Joint Commission/Great Lakes Levels Board U.S. Army Corps of Engineers U.S. Federal Insurance Administration Minnesota Dept. of Natural Resources Minnesota Office of Emergency Services Regional Development Commissions Local Governments	Control of water level in Lake Superior. Study flood problems, plan & construct flood control structures. Delineate flood hazard areas, administer flood insurance program. Establish minimum standards for flood plain management. Draft & maintain a state disaster preparedness plan. Comprehensive regional land use planning; performs shoreline damage surveys. Must adopt flood plain management ordinances, including land use controls, meeting state minimum standards, for all lands subject to flooding by 100 year recurrence interval floods. DNR will establish minimum regulations which each body must meet. If ordinance is inadequate or not developed, DNR will intervene until regulations are met.	See Ref. 56 U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Awaits FIA 100 year flood plain designation. Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	Portions of Lake County & Duluth area: 2% critical erosion, 7% significant erosion, 91% stable. See Ref. 56	Short-term effects caused by winter storms occurring during years of high water levels in Lake Superior (2 ft. above normal water level), especially during late fall, early winter & early spring. See Ref. 56 Long-term effects due to wave & ice action, & mechanical break-up of rocky beaches presently unknown.	Little hazard to life; loss of recreational & residential beach areas estimated at $828,000 in 1951-1952 high water period. See Ref. 56	Increasing slowly; aggravated by maintenance of higher lake stages superimposed on high wave run-up.	International Joint Commission/Great Lakes Levels Board U.S. Army Corps of Engineers Minnesota Dept. of Natural Resources Regional Development Commissions Local Governments	Control of water level in Lake Superior. Study coastal erosion problems, plan & construct erosion control structures. Establish minimum standards (type of land use, setbacks, etc.) for shoreland development. Comprehensive regional land use planning; performs shoreline damage surveys. Must adopt shoreland development ordinances meeting state minimum standards for all lands within 1000 ft. of shoreline, or within 300 ft. of landward side of flood plain, whichever is greater.	See Ref. 56 U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Hazard areas have been designated but establishment of regulations awaits planning reports.

MISSISSIPPI

Mississippi has only three counties, Hancock, Harrison and Jackson, with coastline. Much of the 359 miles of tidal shoreline is marshland and artificial beach (U.S. Dept. of Commerce, 1971). Uses of this coastal zone are varied and include residential, recreational, shipping, commercial fishing and heavy industry. Growth has been rapid, population near the shore increased forty-two per cent (42%) between 1960 and 1970 (U.S. Department of Commerce, Bureau of the Census, 1970).

Natural hazards of concern in Mississippi are coastal erosions, hurricanes and flooding. During any given year, it has been estimated that Mississippi has a six per cent (6%) chance of experiencing a direct hurricane landfall (Simpson and Lawrence, 1971). Hurricane Camille, of August 1969, caused nearly a billion and a half dollars damage to the Mississippi Gulf Coast (Mississippi, State of, 1970).

Coastal erosion is a continuous problem along parts of the shoreline; barrier islands and artificial beach areas are particularly vulnerable. The U.S. Army Corps of Engineers, in its South Atlantic regional report to the National Shoreline Study (1973a), reports twenty-eight per cent (28%) of the shoreline is undergoing noncritical erosion and an additional fifteen per cent (15%) is suffering critical erosion damage.

Coastal flooding caused by storm surge and associated riverine flooding is another hazard of concern in Mississippi. Flooding of marshes and low-lying wetlands along the shoreline is a common problem and may cause damage to property during periods of heavy precipitation and storm surge associated with hurricanes and storm systems.

Table IV-17 shows the nature of the natural hazards in the Mississippi coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

At the heart of natural hazards management in Mississippi is the Coastal Wetlands Protection Act of 1973, which invests the Marine Resources Council with the authority to issue permits regulating construction and other modifications in wetlands areas. Cities, incorporated towns and counties all have broad zoning and subdivision authorities.

TABLE IV-17

NATURAL HAZARD MANAGEMENT IN THE MISSISSIPPI COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Entire coast vulnerable.	6% probability of hurricane effects in any given year, 1% probability of a great hurricane. See Ref. 41 1% probability of a 12 ft. storm surge near Gulfport. See Ref. 41 1900-1974 - 5 hurricanes, 3 of which were great hurricanes. See Ref. 13 Major events: 1915, 1965 (Betsy), 1969 (Camille).	Tornadoes, rain, wind, storm surge, accelerated erosion. 1969 (Camille) - 260 dead, $1.4 billion damage. $55 million spent by Corps of Engineers for reconstruction along Mississippi Gulf coast area. See Ref. 56	30.2% population increase since last major hurricane. See Ref. 13 Increasing development of coastal areas adds to vulnerability. Inexperienced population may not respond adequately to evacuation warnings.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) Mississippi Civil Defense Council	Construction of storm surge protection structures. Collects and disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	15% critically eroding, 28% noncritical, 57% stable. See Ref. 55 Barrier islands & artificial beaches especially vulnerable.	Chronic, accelerated by storms.	Damages beaches, protective works, buildings, roads, etc. Some threat to property; shoreline changes may pose navigation threat.	Population increase on mainland increases future vulnerability. Barrier islands generally undeveloped.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Mississippi Marine Resources Council Gulf Coast Research Laboratory	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Permitting of dredge & fill applications. Technical studies of coastal stratigraphy.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding. Coastal Wetlands Protection Act of 1973.
Coastal Flooding	Marshes & low-lying coastal areas.	Flooding caused by hurricanes & local storms. Flooding of wetlands is common. Not a major problem, except when tides are higher than normal.	Damage to structures in flood plain. Property damage low, except when storm conditions present.	Existing controls probably adequate to keep property-at-risk low.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Mississippi Marine Resources Council Mississippi Civil Defense Council	Study coastal flood problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Program. Permitting of dredge & fill applications, effect on ebb & flow of tide included as a criterion for permitting. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Coastal Wetlands Protection Act of 1973. Responsible under Sec. 201 of PL 93-288.

NEW HAMPSHIRE

The New Hampshire coastal area is a roughly triangular shaped drainage basin in the extreme southeastern corner of the state. It is bounded by the Piscataqua River Basin on the north and west, by the Merrimack River Basin on the southwest, and by a narrow strip of the Massachusetts north coastal area on the south for a total of 131 miles of shoreline.

The topography consists of a gently rolling plain with typical elevation of 20 to 80 feet, with several drumlins reaching elevations above 200 feet. There are seventeen tidewater cities and towns in the area, of which only four front directly on the Atlantic Ocean. The other thirteen front on tidal rivers, Great Bay, or saltwater marshes. There are also numerous fresh-water marshes in this area. Most of the surficial deposits are marine clays and sand which were uplifted following glacial retreat.

The entire coastal area is vulnerable to erosion with the most critical problems occurring at Hampton Beach, North Beach, Seabrook Beach, Hampton, Foss Beach and Rye. Flooding problems have also occurred, mainly in conjunction with hurricanes and northeasters, which occasionally have direct impact on the coast. Generally overlooked as a hazard in New Hampshire, is the possibility of a damaging earthquake. Although considered of low probability, a catastrophic event could take place.

Table IV-18 shows the nature of the natural hazards in the New Hampshire coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The New Hampshire Coastal Zone Management Office is located within the Office of Comprehensive Planning's Division of Regional Planning. The Coastal Zone Management Office has designated Geographical Areas of Particular Concern and has instituted a number of data gathering studies for the coastal zone.

Cities and towns have broad powers to zone, but villages must be specifically authorized to zone by the legislature. All regulations must be in compliance with a comprehensive plan for that municipality.

The state passed a Tidal Wetlands Law (1973) which defines wetland areas and permissible uses for these areas. The law was tested in the New Hampshire Supreme Court and upheld (Sibson v. New Hampshire, 1975).

The state is in the process of formulating its coastal management policies, and state-level guidelines for local implementation are expected.

TABLE IV-18

NATURAL HAZARD MANAGEMENT IN THE NEW HAMPSHIRE COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Entire coast susceptible to erosion-triggered landsliding. See Ref. 10 5% of coast critically eroding, 90% noncritical erosion, 5% stable. See Ref. 53	Continual process accelerated by storms.	Undermines bank (& buildings), removes beaches, contributes to sedimentation problems. $5.2 million estimated cost to protect 2 miles of coast. See Ref. 54 Feb. 1972 - storm destroyed beaches; area declared National Disaster. Beach restored by Federal government.	Low catastrophe potential; increasing development adds to damage potential.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration New Hampshire Office of Coastal Zone Management located within the Office of Comprehensive Planning Water Resources Board	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Designate Geographical Areas of Particular Concern (GAPC). Administers Tidal Wetlands Law (1973)	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.
Coastal Flooding	No major rivers empty on coast. 5-6 towns in coastal area identified by FIA as having flood hazard, including Portsmouth.	Caused by snow melt, hurricanes, northeasters, local storms. Once every 2 years tides can be expected to exceed mean high water by 3 ft. or more.	Accelerated erosion, damage to buildings. Spring tide of 1959 - 8.6 ft above mean sea level along south coast. See Ref. 6	Development of coastal zone, especially marshes, may increase vulnerability to fresh & salt water flooding.	U.S. Geological Survey U.S. Army Corps of Engineers U.S. Federal Insurance Administration New Hampshire Office of Coastal Zone Management located within the Office of Comprehensive Planning Office of Comprehensive Planning Water Resources Board	Prepare flood-prone area maps. Study coastal flooding problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Designate Geographical Areas of Particular Concern (GAPC). Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Administers Tidal Wetlands Law (1973).	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288.
Hurricane	Entire coast exposed.	Slight probability of hurricane effects. See Ref. 41 1900-1974 - 1 minor hurricane direct landfall. See Ref. 13 Past events: 1915, 1960 (Donna).	Indirect effects: rain, flooding, high tides, & accelerated erosion.	Inexperience with direct landfalls may hinder evacuation. Susceptibility increases with coastal development.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) Office of Comprehensive Planning U.S. Geological Survey	Construction of storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Prepare flood-prone area maps.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288.
Earthquake	Moderate damage expected along coast. See Ref. 2	117.6 modified Mercalli maximum intensity V earthquakes per 100 years expected. Maximum intensity expected, IX. See Ref. 61	Low probability event could cause catastrophe, depending on location. Little experience with earthquakes.	Increasing with development of coastal zone.	U.S. Geological Survey New Hampshire State Geologist's Office Office of Comprehensive Planning	Conducts geological studies in order to monitor & possibly predict seismic activity. Technical studies of geology & soils. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288:

There are 1792 miles of tidal shoreline in the New Jersey coastal zone (U.S. Department of Commerce, 1971); steep basalt cliffs in the north, along with glacial outwash sands and tidal wetlands. The Atlantic oceanfront stretches along 126 miles of narrow, sandy barrier islands and beaches. The eight-five mile Delaware Bay shoreline consists of uninhabited tidal wetlands with a few fishing communities, a nuclear power plant and industrial warehouses on the shore of the Delaware River.

Coastal erosion and flooding are the most significant natural hazards in the New Jersey coastal zone, although hurricanes do inflict infrequent damage. Northern sectors of this shore have a one per cent (1%) chance of experiencing a hurricane impact each year (Simpson and Lawrence, 1971). Erosion is worst along the Atlantic oceanfront where losses of up to sixteen feet per year are common. Approximately eighty per cent (70%) of this shoreline is classed as critically eroding. Elsewhere, erosion is critical along five per cent (5%) of the Delaware Bay shore and most of Raritan Bay (U.S. Army Corps of Eng., 1971c). While housing is often in jeopardy, loss of protective and recreational beaches is more frequent. Erosion is triggered by winter storms but is also exacerbated by the great number of groins, bulkheads, jetties and other shore protection devices which intercept littoral sediment supplies and otherwise affect beach processes.

Tidal and riverine flooding are serious problems throughout the entire shorefront. On occasion, however, floods have had a beneficial effect on the physical environment, as when recovery of the moribund Hackensack Meadows tidal wetlands followed on the heels of a 1950's hurricane which destroyed abandoned dikes constructed in an abortive 19th century reclamation project.

Areas along the south shore of Raritan Bay were extensively inundated in March 1962 and the oceanfront barrier islands were breached and flooded in several places. This storm killed fourteen persons on the Jersey shore and injured more than 1,300, destroying nearly 2,000 buildings and damaging 14,000 more. Overall public and private losses were estimated at $80 million (1962 figures) (New Jersey Almanac, 1966-67).

Delaware Bay flooding is less severe because few people live near the shore. In contrast, much of the Delaware River shore suffered heavy riverine flood damages due to hurricane-generated rainfall in 1955. One hundred lives were lost and property damage of $100 million was sustained. The U.S. Corps of Engineers estimates that a repetition of the design flood could produce $2 billion damages from tidal flooding in northern New Jersey. On the oceanfront, damages from a similar flood could reach $260 million with half of that total being sustained by communities on Raritan and Sandy Hook Bays (U.S. Army Corps of Eng., 1971c).

Table IV-19 shows the nature of the natural hazards in the New Jersey coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The cornerstone of hazards management in the New Jersey coastal zone lies in the Coastal Area Facility Review Act of 1973 and the Wetlands Act of 1970, administered by the New Jersey Department of Environmental Protection (DEP). Both utilize a strict permit system to regulate development in the coastal zone, thus reducing potential loss from natural hazards. New Jersey has established special districts in two coastal areas. The Hackensack Meadowlands Development Commission possesses comprehensive regional zoning and planning powers but the Pinelands Environmental Council has only weak ability to review and delay development for a ninety day period. Responsibility for comprehensive planning and zoning remains with the local governments.

TABLE IV-19

NATURAL HAZARD MANAGEMENT IN THE NEW JERSEY COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	26% of shoreline is critically eroding, 23% noncritical erosion, 51% stable. See Ref. 53 Atlantic shore is more vulnerable than Delaware River coast.	Continual process accelerated by storms.	Damages buildings, roads, protection works, beaches, bluffs. 1962 high waters breached a dike; 40-50 residences flooded. Mar. 1962 storm - beaches moved hundreds of feet inland, buildings destroyed, roads made impassible. See Ref. 56	Increasing with increased development.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					N.J. Dept. of Environmental Protection	Responsible for coastal protection under its duties of administering the Coastal Area Facility Review Act (CAFRA, passed June 20, 1973).	
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					Municipal Governments	Adopt zoning ordinances, building codes, setback lines, & land use regulations.	
Coastal Flooding	Low-lying coastal areas.	Caused by hurricanes, severe storms.	Mar. 1962 - 14 dead, much flooding from successive high tides. See Ref. 32 May 1968 - 100 communities flooded, $29 million damage. 1971 - 200 communities flooded by Doria's rains. 1973 - rains flooded Raritan River Basin, $23 million damage. See Ref. 56	Increasing with increasing development.	N.J. Dept. of Environmental Protection	Designates flood plains. Adopts rules & regulations concerning land use & development in designated flood plains.	
					Delaware River Basin Commission	Authorized to study & determine the nature & extent of the flood plain of the Delaware River, to classify land & establish standards for flood plain use.	
					Municipal Governments	Adopt zoning ordinances, building codes, setback limits & land use regulations.	Must adopt regulations meeting state standards or state will intervene.
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Act.	See Ref. 31
					U.S. Army Corps of Engineers	Study coastal flooding problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					N.J. Dept. of Defense/Division of Civil Defense & Disaster Control	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Hurricane	Entire coast exposed. Southern coast most vulnerable. Long Beach resort area poses serious problems for successful evacuation efforts.	1% probability of hurricane effects. See Ref. 41 1900-1974 - 1 hurricane Landfall. See Ref. 13 Major events: 1944, 1960 (Donna), 1968, 1971 (Ginger), 1973 (Doria).	Rain, wind, storm surge, tornadoes, accelerated erosion. Most damage is from flooding (see above).	Inexperience of population with major hurricane may hinder evacuation. Increasing development of coast contributes to vulnerability.	U.S. Army Corps of Engineers	Construction of storm surge protection structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					National Weather Service (NOAA)	Collects & disseminates meteorological information. Issues hurricane warnings.	
					National Hurricane Center (NOAA)	Issues warnings, disseminates hurricane information.	
					N.J. Dept. of Defense/Division of Civil Defense & Disaster Control	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

New York has three coastal zones: oceanic, lakeshore and riverine.

Oceanic Coast: New York City, Westchester County and Long Island are fringed by 1850 miles of tidal shoreline (U.S. Dept. of Commerce, 1971). Approximately 330 miles of this is classified as beach and the remainder as high cliffs and rocky bluffs.

Natural hazards affecting the oceanic coast are primarily coastal flooding, erosion and the slumping of coastal bluffs or landsliding.

Most of the oceanfront coast is classed as critically eroding (128 miles) due to coastal flooding caused by tidal action and storm surge. Additionally, hurricanes have a six per cent (6%) chance of affecting this coastline every year. In addition, damaging winter storms exacerbate the erosion and landslide problems. In 1938, nineteen lives and numerous homes were lost in Westhampton Beach during a severe hurricane. In 1962, twenty-nine homes were destroyed and several million dollars property damage incurred, again due to the devastating effects of a hurricane (Mitchell, 1974).

Lakeshore Coast: Eleven New York counties occupy 360 miles of Lake Erie and Lake Ontario shoreline. This shoreline is characterized by bluffs of glacial outwash material and range in height from ten to twenty feet at the western end of Wayne County on Lake Ontario to over 100 feet in Chautaugua County on Lake Erie. Marshes, barrier beaches and sand dunes exist along various stretches of the Great Lakes shoreline.

Coastal erosion and flooding are the chief natural hazards on the Great Lakes shores. High water levels during the periods from 1951-52 and 1972-74 inflicted heavy damage along most of the shore. Bluffs receded under direct wave attack aided by frost, seepage and surface erosion. Low-lying districts to the west of Rochester were particularly hard hit. On Lake Ontario the highest water levels are reached at the eastern end, where damages have been severe in the past. Summer homes and permanent residences were flooded for several months and the shore was heavily eroded. In 1951-52 $12.7 million (1970 dollars) in property damage was inflicted. Even greater losses occurred during the more recent period (Palm, 1975). On Lake Erie the highest water levels generally occur in Buffalo Harbor - the point of maximum fetch - but here damages are minor. At present, fifty-four per cent (54%) of the Great Lakes coastline is eroding, but only 4.5% can be considered critical. Coastal flooding critically threatens about twenty miles, at present (U.S. Army Corps. of Eng., 1971c).

In New York there is an indeterminate risk of major earthquake damage. Little information as to causes or characteristics of New York earthquakes exists. No quakes of serious intensity have occurred in New York in recent times.

Hudson Valley Shoreline - The Hudson River is tidal for approximately 170 miles above New York City. There is little detailed information on natural hazards for this sector of the state's coastal zone. Riverine flooding, shore erosión and landslides are problems along small sections of the waterfront. In addition, the Ramapo fault, which extends into the lower Hudson Valley from New Jersey, has been active in recent years.

The 1973 Tidal Wetlands Act and the 1973 Stream Protection Act provide tools for flood hazard management in New York by authorizing the State Department of Environmental Conservation to regulate development of these areas through the issuance of permits. In addition, Article 36 of the New York Environmental Conservation Law (1974) "requires local participation in the National Flood Insurance Program with provisions for state adoption of flood control measures in communities which fail to qualify for NFIP". The former New York Office of Planning Services has prepared model zoning ordinances for flood hazard areas (N.Y. State Dept. of Env. Conservation & N.Y. Planning Services, 1974). (See N.Y. State General City Law, Chapter 21 of Consolidated Laws, Art. 2-A; N.Y. State Village Law, Ch. 64 of Consolidated Laws, Art. VI-A; and N.Y. State Town Law, Ch. 62 of Consolidated Laws, Art. 16.)

The Department of State has responsibility for administration of the state's coastal zone management program.

Table IV-20 shows the nature of the natural hazards in the New York coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

TABLE IV-20

NATURAL HAZARD MANAGEMENT IN THE NEW YORK COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	Hudson River, Long Island Sound & low-lying coastal areas. 19.1 miles of Great Lakes shoreline subject to flooding. See Ref. 51 Lake Ontario shoreline.	Flooding caused by hurricanes, severe storms, temporary high lake levels. March 1973 severe winter storm. Early spring high lake levels. 1972-74 caused serious flooding. April 1973 Lake Ontario reached record high. See Ref. 36	Damage to structures in flood plain, accelerated erosion, recurrence of tidal flood of record could cause $320 million (1970) damage on Long Island & adjacent N.J. shores. Additional $2.5 billion (1958) potential losses in New York City harbor. See Ref. 34 Lake Ontario flooding resulted in millions of dollars in property damages in Oswego County, N.Y. See Ref. 37	Deregulation of barrier islands increases damage potential. Susceptibility slowly increasing.	U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Act.	See Ref. 31
					U.S. Geological Survey	Prepare flood-prone area maps.	
					International Joint Commission: a. International Niagara Board of Control	a. Supervises operation of remedial works on Niagara River & controls river water levels.	See Ref. 56
					b. International St. Lawrence River Board of Control	b. Regulates Lake Ontario levels & outflows through St. Lawrence River.	See Ref. 56
					c. Great Lakes Levels Board	c. Control of water levels in Great Lakes.	Undertaken Great Lakes Water Levels Study which incorporates assessment of practicable ways of improving flood control throughout Great Lakes.
					N.Y. Dept. of Environmental Conservation	Required to assist communities in preparation of flood plain control measures.	Permitting agency for construction in the 100 year flood plain.
					Former N.Y. Office of Planning Services	Proposed Model Zoning Ordinances for flood hazard areas.	
					Local Governments/ Regional & County Planning Boards	Must adopt flood plain regulations in compliance with standards set by N.Y. Dept. of Environmental Conservation.	Dept. of Environmental Conservation can impose regulation on localities if they fail to enact their own (not proven to be necessary).
					N.Y. Division of Military & Navy Affairs	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 10 Executive Law, as amended by Ch. 931, Laws of 1973.

TABLE IV-20 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE NEW YORK COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Atlantic coast; 32% critical, 52% noncritical, 16% stable. See Ref. 53 Ocean front more vulnerable than bay shores. Great Lakes coast: 4.5% critically eroding, 49.8% noncritical erosion, 45.7% stable. See Ref. 51 Lake Ontario coast most affected.	High water levels & storms accelerate erosion; Continual process. Maximum erosion of 5 ft. per year at Wilson Harbor (1875-1939). See Ref. 51 April 1973 Lake Ontario reached record high level. See Ref, 36	Damages buildings, roads, protection works, beaches, bluffs, etc. Annual damages on southern Long Island shore: $75,000 per mile. See Ref. 54 1951-1952 high lake levels caused about $12.7 million damage. See Ref. 51 1972-74 high lake levels caused serious erosion losses. See Ref. 36	Control of St. Lawrence seaway alleviates to some extent damages from high lake levels. Susceptibility is slowly increasing.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					International Joint Commission/Great Lakes Levels Board	Control of water levels in Great Lakes.	See Ref. 56
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					St. Lawrence-Eastern Ontario Regional Commission	Comprehensive land use planning incorporating high water damage zones.	
					N.Y. Dept. of Environmental Conservation	Administers a Marine & Coastal Resources program which includes beach erosion control.	
					Local Governments/ Regional & County Planning Boards	Establish zoning ordinances, land use controls & construction codes.	Individual communities have invested money in beach nourishment & structural protection.
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
Hurricane	Entire ocean coast exposed.	6% probability of hurricane effects, 1% probability of a great hurricane. See Ref. 41 1900-1974, 6 hurricane direct landfalls, including 4 great hurricanes. See Ref. 13 Major events: 1938, 1944, 1954 (Carol), 1960 (Donna), 1972 (Agnes).	Wind, rain, storm surge, accelerated erosion, tornadoes. 1938 hurricane - 19 dead, 50 cottages destroyed in Westhampton Beach. See Ref. 29 Donna, 1960 - 36 dead. Belle, 1976 - lower intensities than expected; about 10,000 evacuated.	94.1% population increase since last major hurricane (not including Belle). See Ref. 13 Increasing development, especially on Long Island, increases susceptibility to a great hurricane. Lack of experience with a great hurricane may hinder evacuation. Deregulation of barrier islands adds to damage potential.	U.S. Army Corps of Engineers	Construct storm surge protection structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended. (Supp. 1975).
					National Weather Service (NOAA)	Collects & disseminates meteorological information. Issues hurricane warnings.	
					National Hurricane Center (NOAA)	Issues warnings, disseminates hurricane information.	
					N.Y. Dept. of Environmental Conservation	Administers a Marine & Coastal Resources program which includes hurricane protection.	
					Local Governments/ Regional & County Planning Boards	Identify hazard zones, establish zoning regulations & building codes.	
					N.Y. Division of Military & Navy Affairs	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 10 Executive Law, as amended by Ch. 931, Laws of 1973.

TABLE IV-20 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE NEW YORK COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Earthquake	Minor damage expected along Atlantic coast. Major damage expected along Great Lakes coast. See Ref. 2	Atlantic coast - 69.1 modified Mercalli intensity V earthquakes expected per 100 years. Maximum expected intensity, VIII. Lake Erie & western Lake Ontario 22.1 modified Mercalli intensity V earthquakes expected per 100 years. Maximum expected intensity, VIII. See Ref. 61 Major events: 1737, 1889 earthquakes near New York City, both intensity VII. 1929 Attica earthquake intensity VIII. See Ref. 54 1944 earthquake at Massena registered VIII modified Mercalli & 6.5 on the Richter scale.	Possibility for a major damaging event, depending on its location. No recent earthquakes over intensity VII. Numerous small shocks have caused minor damage. $2 million in damages resulted. See Ref. 47	Seismic details poorly known. Moderate future susceptibility.	U.S. Geological Survey N.Y. State Geological Survey N.Y. Division of Military & Navy Affairs	Conducts geological studies in order to monitor & possibly predict seismic activity. Technical studies of geology & soils. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 10 Executive Law, as amended by Ch. 931, Laws of 1973.

NORTH CAROLINA

The coastline of North Carolina is 301 miles in length, and ranges from undeveloped beaches and marshes to densely developed barrier islands, or 3,375 miles of tidal shoreline when all island coasts are included (U.S. Dept. of Commerce, 1971). There are also vast estuarine areas (over 2,200,000 acres) within the coastal zone, which are particularly vulnerable to damage by natural hazards.

The principal natural hazards in the North Carolina coastal zone are hurricanes, coastal erosion and coastal flooding. Clearly, hurricanes are the most serious and have caused great destruction in the past. As hazard-prone areas are further developed, the potential for destruction increases.

Coastal erosion is also a problem, with fifteen per cent (15%) of the coast subject to critical erosion (U.S. Army Corps of Eng., 1973a). The Outer Banks are particularly vulnerable, and the problem is exacerbated by hurricane storm surge.

A final problem in the North Carolina coastal zone is flooding, with estuaries, river mouths and lowland areas the most susceptible. Hurricanes are the major cause of coastal flooding but some riverine flooding does occur and contributes to the flood hazard in the coastal zone.

Table IV-21 shows the nature of the natural hazards in the North Carolina coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The principal legislation dealing with hazards is the Coastal Area Management Act of 1974. The Act calls for designation of Areas of Environmental Concern (AEC), and some criteria deal with natural hazards. Specifically, the following types of Natural Hazard Areas will likely be included: General; Sand Dunes along the Outer Banks; Ocean Beaches and Shorelines on the Outer Banks; Excessive Erosion Area--General, Coastal Inlet Lands, Ocean Erodible Areas, and Estuarine and River Erodible Areas. The Act states general policy objectives for the coastal area, but directs the Coastal Resources Commission to establish within those guidelines appropriate land and water uses for each AEC it designates. A cooperative state-local permitting process will regulate all development within Areas of Environmental Concern. The Act further requires that local governments prepare their plans in accordance with state guidelines and subject to state review (Bell, 1976).

Local governments (cities, villages, town and counties) have broad zoning and subdivision powers, and special enabling legislation exists which authorizes municipal and county regulations for floodway areas (this is separate from zoning). City and county zoning regulations must comply with comprehensive plans.

Several agencies, most of them within the Department of Natural and Economic Resources, are involved in technical and planning studies. The state also has a building code (which requires mobile home tie-down) and wetlands protection legislation. Nearly all local governments in the coastal zone have enacted sand dune protection ordinances.

TABLE IV-21

NATURAL HAZARD MANAGEMENT IN THE NORTH CAROLINA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Entire coast.	5-11% probability of hurricane effects, depending on section of coast. 2-4% probability of a great hurricane. See Ref. 41 Wilmington - 1% probability of a 12 ft. storm surge. Lower heights expected elsewhere. See Ref. 41 1900-1974 - 19 hurricane landfalls, including 7 great hurricanes. See Ref. 13 Major events: 1933, 1944, 1954 (Carol & Hazel), 1955 (Ione & Connie), 1960 (Donna), 1971 (Ginger).	Rain, flooding, storm surge, tornadoes, wind, accelerated erosion. 1929 hurricane related flooding caused $9 million damage in Georgia, South Carolina, North Carolina, Virginia. See Ref. 15 Potential for massive loss of life & property.	14.1% population increase since last major hurricane. See Ref. 13 Rapid development of coastal areas increases susceptibility.	U.S. Army Corps of Engineers North Carolina Coastal Resources Commission National Weather Service (NOAA) National Hurricane Center (NOAA) North Carolina Division of Civil Preparedness	Construction of storm surge protection structures. Promulgates rules & regulations for land use in high hazard areas. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended. (Supp. 1975). Hazard areas are defined as land areas on outer banks or barrier islands with a probability of 1% or greater annually of being flooded by a hurricane. Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	15% of coast critically eroding, 20% noncritical erosion, 65% stable. See Ref. 55 Outer banks especially vulnerable.	Continual process accelerated during storms. 1940-1965 average recession rate of 3-5 ft. per year at Nags Head. See Ref. 6	Damages buildings, roads, protection works, beaches. Sedimentation obstructs shipping routes.	Increasing with increasing coastal development.	North Carolina Dept. of Natural & Economic Resources County Governments U.S. Federal Insurance Administration U.S. Army Corps of Engineers	Administer Coastal Area Management Act. Establish land use plans to provide protection of coastal dunes & areas subject to erosion by water or high winds. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Study coastal erosion problems, plan & construct erosion control structures.	Critical erosion areas are defined as those which erode at a rate of more than 10 tons per acre per year. Coverage limits are the same as for coastal flooding. U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
Coastal Flooding	Estuaries, wetlands, river mouths, low-lying coastal areas.	Caused by hurricanes, severe storms. Flooding of wetlands is fairly common.	Damage to buildings, structures in flood plain; accelerated erosion. Mar. 1962 storm - tide fo 7-9 ft. above mean sea level at Nags Head, over $1.5 million damage from storm. See Ref. 6 Little damage from freshwater flooding.	Increasing vulnerability to salt water flooding. Slight susceptibility to riverine flooding.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration North Carolina Division of Civil Preparedness Local Governments	Study coastal flooding problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Delineate floodways, issue permits for uses in the floodway.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288. If local governments fail to delineate, State Board of Water & Air Resources can delineate the floodway.

OHIO

The Great Lakes mainland shoreline in Ohio is 265 miles in length, and includes such major urban areas as Cleveland, Sandusky and Toledo. The landscape of this shoreline varies greatly from west to east. Beginning at the western end of Lake Erie with low-lying marshes and barrier islands the elevation gradually rises, marshes slowly give way to bluffs ten to thirty feet in height. From the Cedar Point area and continuing east, a few marshes remain but bluffs are the predominant landscape feature and sometimes reach elevations of sixty feet.

The bluffs are mainly glacial till and shale and are highly susceptible to erosion, the major natural hazard in the Ohio coastal zone. The entire coastline is vulnerable with 9.2% critically eroding (U.S. Army Corps of Eng., 1971a). Protection, in the form of short seawalls and groins, has been provided for part of the frontage, but has not been particularly effective because of a lack of sufficient beach material.

A second natural hazard affecting the Ohio shoreline is flooding, which occurs mainly as a result of severe easterly storms. Artificial dikes extend into the lake at several points, but these have been breached a number of times in the past.

A final hazard which is often overlooked in Ohio is earthquake. A number of small shocks have caused minor damage in the past, and the possibility exists that a larger event could cause a great deal of damage.

Table IV-22 shows the nature of the natural hazards in the Ohio coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The Ohio Lake Erie Shore Planning Region includes nine counties with 159 cities and villages and 210 townships. In addition, there are thirty-seven district, regional, county and municipal planning agencies in the Shore Zone Planning Region.

The major focus of authority in the Ohio coastal zone lies within the local governments which have the power to establish building codes, zoning ordinances and other land use regulation measures.

At present, Ohio has not implemented a mechanism which will permit state-level comprehensive planning in the coastal zone. Plans do exist, however, to introduce a bill to the legislature creating a Shoreland Regional Commission, which will be responsible for implementing the program through existing state and local government authorities (McPherson, 1976).

TABLE IV-22

NATURAL HAZARD MANAGEMENT IN THE OHIO COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Entire Lake Erie shoreline is subject to erosion, except in isolated areas. 9.2% critically eroding, 36.6% noncritically eroding, 54.2% stable or protected.	Accelerated by storms, high lake levels. 1939-1949 - 4-5 ft. per year between Cedar Point & Huron. See Ref. 51	Damages buildings, roads, beaches, bluffs. $14.8 million damage between May 1951 & Apr. 1952. 1969 less serious, but still severe damage. See Ref. 51	Continued erosion will cause buildings to be endangered, even with setback lines.	International Joint Commission/Great Lakes Levels Board	Control of water level in Great Lakes.	See Ref. 56
					U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Local Governments	Establish zoning ordinances, building codes, & land use management programs.	
					Ohio Geological Survey	Preparing reports which include recession trends, inventory of control structures & county erosion problem summarics.	
Coastal Flooding	Low-lying areas, small flood plains near lake shores. 20 mile section east of Toledo.	Coast east of Toledo flooded in 1952 & 1969 by high lake levels. Floods also due to rain, compounded by ice jams in some cases.	Damage to buildings in flood plain, accelerated erosion. Protective dikes breached in 1943 & 1952. Mar. 1933 - general flooding from rainfall.	Increasing with development of flood plain.	International Joint Commission/Great Lakes Levels Board	Control of water level in the Great Lakes.	Undertaken Great Lakes Water Levels Study which incorporates assessment of practicable means of improving flood control throughout Great Lakes.
					U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Program.	See Ref. 31
					U.S. Geological Survey	Prepare flood-prone area maps.	
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Ohio Disaster Services Agency	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Local Governments	Establish zoning ordinances, building codes & land use management programs.	
					Ohio Dept. of Natural Resources/Division of Water	Permitting agency for construction activities within flood plains.	
Earthquake	Entire coast.	22 modified Mercalli maximum intensity V earthquakes expected per 100 years. Maximum intensity expected, VIII. See Ref. 61	A number of small shocks have caused minor damage. Possibility of a larger earthquake causing considerable damage.	Slowly increasing with increasing development.	U.S. Geological Survey	Conducts geologic studies in order to monitor & possibly predict seismic activity.	
					Ohio Division of Geological Survey	Technical studies of geology & soils.	
					Ohio Disaster Services Agency	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

OREGON

The Oregon tidal shoreline is 1,410 miles, including about thirty miles of the lower Columbia River estuary (U.S. Department of Commerce, 1971).

The Oregon coastal zone faces varied and severe natural hazards: flooding, tsunamis, coastal erosion, landslides and earthquakes.

Flooding is a major problem. Large, damaging floods are estimated to occur on an average of every five or six years. The State Water Resources Board reports average annual damages of about $3,500,000 in seven of the major coastal drainages. Major floods occurred at Christmas time in the winter of 1964-65, and the entire state was declared a disaster area. Damage in Tillamook County alone was estimated as in excess of $8,300,000. Creeks too small to be named became torrents.

Tsunamis are a recurring threat, but most of the warnings do not necessarily result in significant events. The tide recorder at Newport has recorded three tsunamis, all minor, since installation in January 1967. The only destructive tsunami in recent years occurred in March 1964 with the Alaskan earthquake and resulted in four deaths and an estimated $700,000 in property damage. The recurrence interval for major tsunamis is estimated to be one in 100 years (Beaulieu, et al., 1974).

The erosion of sand beaches and dunes, and the landsliding of cliffs and bluff faces are particularly serious hazards during the winter months due to heavy precipitation and strong wind and wave action.

The earthquake hazard is considered moderate to severe along portions of the northern and southern coasts of Oregon.

A major problem is that various hazards combine synergistically to produce unusually severe events. For example, flooding from heavy and prolonged winter precipitation frequently is compounded by high winter tides and strong onshore winds. Winds can push a normal six or seven foot tide to a height of twelve feet or more. The same precipitation has on occasion caused landslides in the steep-sided coastal mountain valleys, creating temporary lakes that can burst suddenly to further compound the flood problem. Much of the Oregon coastline is made up of marine terraces composed of relatively soft rocks. Periodic failures of the cliff faces occur at the seaward edge of the terraces under the combined impact of strong wave attack and heavy precipitation. A coincident earthquake could cause a massive disaster.

Table IV-23 shows the nature of the natural hazards in the Oregon coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures. Locally coordinated comprehensive plans will provide the major vehicle for implementing Oregon's Coastal Management Program. These plans are subject to review and approval by the Oregon Land Conservation and Development Commission (LCDC), created in 1973 by the Oregon Land Use Act. All levels of government must conform with goals and guidelines adopted by LCDC. Should a local government fail to comply, the 1973 act provides that LCDC shall prescribe and administer a comprehensive plan for that locality, and be reimbursed for the cost of this effort from that locality's share of the state's cigarette and liquor revenues. Currently (1976), the LCDC is circulating draft coastal zone goals and guidelines for review. These goals and guidelines require that all coastal development be planned to minimize the threat to life and property from natural hazards.

TABLE IV-23

NATURAL HAZARD MANAGEMENT IN THE OREGON COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	Estuaries & river mouths of the Oregon coast basin, beaches, dunes & dune deflation plains.	Floods due to snow melt &/ or rain. Winter & spring floods most common. Major floods every 5-6 years. See Ref. 3	Heavy property damage. Effects may be compounded by high tides & failure of temporary dams. 1964 winter floods - entire state declared disaster area. Tillamook County $8.3 million damage. See Ref. 35 Coastal flooding is a serious problem in inter-dune systems.	Upstream flood control projects protect lower Columbia basin. Development in flood plains of other streams increases susceptibility. Most floods don't occur in summer tourist season.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration U.S. Geological Survey Oregon Water Resources Dept. Oregon Land Conservation & Development Commission Local Governments	Study coastal flood problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Prepare flood-prone area maps. Planning Flood plain criteria for land use planning Establish zoning ordinances, building codes, & land use management programs.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31
Tsunami	Entire coastal area is vulnerable, including estuaries in extreme events. Low-lying areas will have largest run-up. See Ref. 2	Impulsive disturbance in ocean generates a series of long waves which build in height as they approach shore. See Ref. 2 Estimated average of 1 tsunami per 100 years; run-ups of 20 ft. above high tide possible. Warning time: 6-10 hrs. for distant-origin tsunamis; less than 1 hr. for local-origin tsunami.	High catastrophe potential. Origin of tsunami, magnitude, configuration of coast & extent of development contribute to damage potential.	Slight reduction with improved warning system. Inexperience with tsunamis may contribute to damage potential. Susceptibility increasing with more recreational activity & coastal development.	National Weather Service (NOAA) State & Local Police Oregon State Executive Dept./ Emergency Services Division	Collects & disseminates meteorological information; issues tsunami warnings. Warnings; evacuations & relief. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	Of the ocean exposure: 17% critical erosion, 26% noncritical erosion, 57% stable or non-eroding. Bay & estuary coasts much less vulnerable. Clatsop, Tillamook, Lincoln, Curry, & Lane Counties have critical erosion problems. See Ref. 50	Continual process accelerated by storms, especially in winter.	Slight hazard to life. Estimated cost of $43.85 million to protect shore using beach nourishment, revetments & groins. See Ref. 54 Damages roads, buildings & other structures as well as beaches, bluffs, etc.	Increasing with increasing development.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration State Dept. of Geology State & Local Highway Dept. Oregon Land Conservation & Development Commission Oregon Dept. of Transportation Local Governments	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Planning & research. Location, design & construction of roads. Statewide planning. Regulation of beaches. Planning, zoning, building, & subdivision control.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding. Render assistance to local governments with inventories, evaluations & criteria for land use planning.

TABLE IV-23 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE OREGON COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Landslide	Major severity along coast, particularly northern & southern coasts. See Ref. 69	May be triggered by earthquakes, coastal erosion, rain, man's activities; materials involved are rock, debris or soil moving in a fall, slide, or flow. See Ref. 43	Effects concentrated in small area unless transportation, utility, or other regional network disrupted. See Ref. 43	Increasing with expanding development, especially residential. Transportation routes also vulnerable.	U.S. Geological Survey Oregon State Emergency Dept./ Emergency Services Division	Research in landslide prediction through the Landslide Hazard Reduction Program. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Earthquake	Moderate damage expected in north & south coastal area. Minor damage expected along central coast. See Ref. 2	Northern coast - Expected 80.1 modified Mercalli maximum intensity V earthquakes per 100 years. Maximum expected intensity VI. See Ref. 61 10 earthquakes modified Mercalli VI or VII, 1841-1970. Some California earthquakes felt along southern coast. See Ref. 59	Damage to structures, loss of life. May cause fire, tsunami, landslide, avalanche. No earthquakes over VII recorded, 1850-1970. See Ref. 59	Development will increase vulnerability but no large earthquakes expected.	U.S. Geological Survey Oregon State Executive Dept./ Emergency Services Division	Conducts geological studies in order to monitor & possibly predict seismic activity. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

PENNSYLVANIA

Pennsylvania possesses one of the smaller coastal zones in the U.S. This is further subdivided into two contrasting and approximately equal sections on the lower Delaware River and Lake Erie.

Delaware River: Sixty (60) miles of Pennsylvania are fringed by the estuarine shores of the lower Delaware. This area encompasses parts of the city of Philadelphia, and Bucks and Delaware counties. Much of the shore is lined with piers, docks, shipbuilding and repair facilities, and warehouses, together with their associated industrial land uses such as oil refineries and petrochemicals plants. Except in Bucks County, little public open space fronts on the river. Small flood plains, along numerous streams in Delaware County and Bucks County, the shores of the Schuylkill River in Philadelphia, and Tinicum marsh, (which contains 80% of the state's wetlands), are the most significant lightly developed areas in this coastal sector.

Coastal and riverine flooding are the primary natural hazards. Although not severe, the last major flood occurred in 1955. It is estimated that a recurrence of the tidal flood of record would cause damages of approximately $60 million (1970 dollars) along the lower Delaware River (U.S. Army Corps of Eng., 1971a). Most of these would be sustained by areas in the vicinity of Philadelphia.

Lake Erie: Fifty to 180' high erodible bluffs composed of silt and clay overlying shale bedrock occur along most of Pennsylvania's sixty mile Lake Erie frontage (Erie county). Very narrow sand and gravel beaches extend along the toe of the bluffs. Presque Isle, a seven mile long sand split, encloses Erie Harbor. This is a complex and unique geological and biological site.

Shore erosion is the major natural hazard. This is caused by winter storms during periodic high lake levels, and by seiches. Spring sapping, frost action and oversaturation also promote bluff line recession. Six miles of Presque Isle shoreline are classed as critically eroding. Another thirty-six miles of bluff coast suffers non-critical erosions (U.S. Army Corps of Eng., 1971a).

Presque Isle tends to migrate eastward becoming detached from the mainland or breached during severe storms. Continuing efforts to stabilize this feature have resulted in the construction of groins and bulkheads at the neck of the peninsula and a program of sand nourishment along the entire peninsula lakeshore. The 1951-52 high water levels inflicted $1,029,800 worth of erosion damages (1970 dollars) on the Pennsylvania lakeshore (U.S. Army Corps of Eng., 1971a).

Average annual bluff line recession rates of 14.89" along the western half of the shore and 9.34" along the eastern half have occurred during the last thirty-eight years (NARWRS, 1972). A recent report indicates that approximately forty per cent (40%) of 109 bluff top locations surveyed experience critical erosion (Great Lakes Res. Inst., 1975). Private homes and open spaces are most at risk. Proposed construction of a steel mill and a power station in the western section of the shore could add to the erosion hazard potential and may also exacerbate beach migration and starvation problems at Presque Isle.

Earthquakes may also present a hazard to portions of the Pennsylvania coastal zone along the Lake Erie shoreline. U.S. Geological Survey estimates place the seismic risk in the moderate range, at VII or less, on the modified Mercalli scale (Ayre, 1975).

Table IV-24 shows the nature of the natural hazards in the Pennsylvania coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

It is anticipated that Pennsylvania will develop a centralized permitting procedure for future coastal zone development. Implementation for zoning and coastal zone planning has been delegated to local governments and regional agencies (e.g. Delaware Valley Regional Planning Commission; Erie Metropolitan Planning Department).

TABLE IV-24

NATURAL HAZARD MANAGEMENT IN THE PENNSYLVANIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	No major rivers empty into Lake Erie from Pennsylvania.	All lakefront & riverfront communities are participating in Federal Flood Insurance Program.	Recurrence of record tidal flood could cause $60 million damage along lower Delaware River. Philadelphia area most vulnerable. See Ref. 56	Damage potential could increase with development of coast, especially for land-based support activities of off-shore gas & oil development.	U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
	Low-lying areas & small flood plains near Presque Isle subject to flooding.	Last serious flood in 1955. Not a major hazard. See Ref. 51			U.S. Federal Insurance Administration	Administer NFIA & Flood Disaster Protection Program.	See Ref. 31
	Lower Delaware River coast - small flood plains, estuarine shores.				International Joint Commission/Great Lakes Levels Board	Control of water level in Great Lakes.	Undertaken Great Lakes Water Levels Study which incorporates assessment of practicable ways of improving flood control throughout Great Lakes.
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Pennsylvania Dept. of Environmental Resources	Coordinating agency for U.S. Coastal Zone Management Act (1972).	In process of designating flood-prone areas in Delaware River Valley and on Lake Erie shore as Geographical Area of Particular Concern (GAPC).
					Erie Metropolitan Planning Dept./ Delaware Valley Regional Planning Commission	Comprehensive land use planning.	Designated by Dept. of Environmental Resources as lead agency for preparation of Coastal Zone plan segments.
					Local Governments	Must adopt flood plain management ordinances, meeting state minimum standards, for all lands subject to flooding by 100 year recurrence interval floods. Dept. of Environmental Resources may establish regulations if localities fail to enact them.	
					Pennsylvania State Council of Civil Defense	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

TABLE IV-24 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE PENNSYLVANIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Lake Erie shore: 12% critically eroding, 75% noncritical erosion, 13% protected or stable. See Ref. 51	Continual process accelerated by storms, high waters. Lake Erie - average annual bluff recession is 14.9 in. toward west shore; 9.3 in. for east shore (for last 38 years). See Ref. 42	$1.03 million (1970) damage during 1951-1952 high water levels of Lake Erie, mostly in Presque Isle Peninsula. See Ref. 51	Plans for a steel mill & power plant on western shore would increase damage potential and possibly contribute to erosion problems (due to beach starvation) east of plants.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structure structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
	Lower Delaware River shore.	Lower Delaware River - little erosion, mostly from waves generated by ships.		Little change expected along Delaware River.	U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					International Joint Commission/Great Lakes Levels Board	Control of water level in Great Lakes.	See Ref. 56
					Great Lakes Basin Commission	Limited coordination of state activities relating to shore damage via Coastal Zone Standing Committee.	
					Pennsylvania Dept. of Environmental Resources	Coordinating agency for U.S. Coastal Zone Management Act (1972).	In process of designating Geographical Areas of Particular Concern (GAPC).
					Erie Metropolitan Planning Dept.	Comprehensive land use planning.	
					Local Governments	Individual communities have established nourishment and structural protection schemes, generally on cost sharing basis with state & federal agencies (for public lands).	
Earthquake	Lake Erie shoreline.	Expected 22 modified Mercalli intensity V earthquakes per 100 years. Maximum expected intensity, VIII. See Ref. 61	1934 earthquake in Erie, slight damage. See Ref. 59	Slowly increasing with development of coastal areas.	U.S. Geological Survey	Conducts geological studies in order to monitor & possibly predict seismic activity.	
	Lower Delaware River.	Maximum expected intensity, VII. See Ref. 61	Possibility of a moderate earthquake causing substantial damage.		Pennsylvania Dept. of Environmental Resources/Bureau of Topography & Geological Survey	Technical studies of geology & soils.	
			1940 earthquake in Philadelphia caused a swell on Delaware River. Possibility of minor damage. See Ref. 59		Pennsylvania State Council of Civil Defense	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

RHODE ISLAND

Rhode Island possesses about 384 miles of shoreline including peninsulas, islands in Narragansett Bay, and Block Island (U.S. Dept. of Com., 1971). Shorelines facing the open ocean are predominantly beach and sand dune with salt marshes and ponds behind the dunes. Along the more protected shore of Narragansett Bay and the leeward sides of islands, coastal features include steep bluffs of glacial till, narrow sand and cobble beaches, and artificial shorelines.

Rhode Island lies squarely in the path of northward moving tropical storms and hurricanes. Its flood of record was caused by the Great Hurricane of 1938. Major destruction also occurred in the storms of 1954, 1955, and 1960.

Erosion is a major problem in Rhode Island. East Beach in Charlestown, for example, receded approximately seventy-five feet between 1962 and 1975. Beach profiles and erosion records for all coastal towns have been prepared by the University of Rhode Island Coastal Resources Center.

Table IV-25 shows the nature of the natural hazards in the Rhode Island coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The Coastal Zone Management program in Rhode Island is based on the Rhode Island State Coastal Management Act of 1971. This Act created a council with permit authority over all shorelines seaward of mean high tide and over "intertidal salt marshes", "shoreline . . . physiographic features", and certain types of major shore-related facilities wherever located. The seventeen member Coastal Resources Management Council is seeking to protect remaining wetlands and "undeveloped beaches" but finds its efforts somewhat undermined by new development pressures, exacerbated, in part, by the availability of federal flood insurance.

TABLE IV-25

NATURAL HAZARD MANAGEMENT IN THE RHODE ISLAND COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Entire coast vulnerable.	7% probability of hurricane effects, 1% probability of a great hurricane. See Ref. 41 Major events: 1938, 1944, 1954 (Edna & Carol), 1955 (Diane), & 1976 (Belle). 1900-1974 - 4 hurricanes, including 3 great hurricanes. See Ref. 13	Winds, storm surge, rain, flooding, accelerated erosion. Sept. 1938 - record tidal flooding of Narragansett Bay & south coast. Large losses in tidal flooding from hurricanes Carol (1954) Edna (1954). 1938 tidal flooding, 15 ft. above mean sea level. See Ref. 56	13.5% population increase since last major hurricane. See Ref. 13 Fairly experienced population. Future susceptibility depends in part on extent of development in vulnerable areas.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) Rhode Island Defense Civil Preparedness Agency	Construct storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings & disseminates hurricane information. Drafts & maintains a state disaster preparedness plan; coordinates local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288.
Coastal Flooding	Low-lying coastal areas. Urbanized areas.	Flooding caused by snow melt, hurricanes, Local storms & northeasters, tidal surge from hurricanes.	Damage to structures in flood plain, social & economic disruption. 1955 flood of record - rains from hurricane Diane, about $38 million damage in Rhode Island, particularly Woonsocket See Ref. 56 Loss of life depends on warning.	Flood control projects reduce average losses, may increase vulnerability to catastrophic loss.	U.S. Army Corps of Engineers Rhode Island Coastal Resources Management Council U.S. Federal Insurance Administration U.S. Geological Survey Rhode Island Defense Civil Preparedness Agency	Study coastal flooding problems, plan & construct flood control structures. Issues permits for virtually all uses in the coastal zone. Administers NFIA & Flood Disaster Protection Act. Prepares flood-prone area maps. Drafts & maintains state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	7% of shore critically eroding, 91% noncritical erosion, 2% stable. See Ref. 53	Continual process accelerated by storms. East Beach, Charlestown receded about 75 ft. between 1962 & 1975.	Undermines structures, depletes important beaches, damages protective works.	Development of coastal areas increases future vulnerability.	U.S. Army Corps of Engineers Rhode Island Dept. of Natural Resources/ Division of Coastal Resources Rhode Island Coastal Resources Management Council Local Governments U.S. Federal Insurance Administration	Study coastal erosion problems, plan & construct erosion control structures. Processes permit requests for use of coastal zone. Issues permits for virtually all uses in the coastal zone. Establish zoning ordinances, construction codes, & land use controls. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.
Earthquake	Minor damage expected along coast. See Ref. 2	Expected 69.1 modified Mercalli maximum intensity V earthquakes per 100 years. Maximum intensity expected: VIII. See Ref. 61 Major events: 1965, 1967. Both intensity V. See Ref. 59	Possibility of a large earthquake. Problem compounded by lack of experience with earthquakes.	Slowly increasing with coastal development.	U.S. Geological Survey Rhode Island Defense Civil Preparedness Agency	Conducts geological studies in order to monitor & possibly predict seismic activity. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

SOUTH CAROLINA

The tidal shoreline of South Carolina consists of 2,876 miles, much of which is formed by numerous barrier islands. The Atlantic coastal shore of South Carolina consists of straight reaches of sandy shore interrupted by many inlets (U.S. Dept. of Commerce, 1971).

South Carolina's coastal zone is subject to the impacts of several natural hazards: hurricanes, floods, coastal erosion, and earthquakes.

Between 1900 and 1974, South Carolina suffered the effects of ten hurricanes, three of which produced major loss of life and property. Often associated with the hurricane hazard is damage by heavy wind, rain and flooding. The flood hazard is particularly serious in the city of Charleston, South Carolina, where nearly all of the city lies below the 100 year storm surge level.

Coastal erosion, a continuous process, is accelerated during storms and hurricanes. Approximately seventy-five per cent (75%) of the South Carolina shoreline is subject to erosion and about thirty per cent (30%) or fifty-seven miles is undergoing critical erosion (U.S. Army Corps of Eng., 1975).

Although no clearly defined fault lines have been identified, South Carolina experienced a major earthquake (X on the modified Mercalli scale) in 1886 and the prospect of future earthquake damage should be taken into account in coastal planning.

Table IV-26 shows the nature of the natural hazards in the South Carolina coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

At present, South Carolina has no legislation which would allow the state to set construction guidelines in hazard-prone areas. It should be noted, however, that critical area legislation has been passed on two occasions by the state legislature only to be vetoed by the Governor.

TABLE IV-26

NATURAL HAZARD MANAGEMENT IN THE SOUTH CAROLINA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Entire coast vulnerable, including Charleston.	5-8% probability of hurricane effects, 1-2% probability of a great hurricane in any given year. See Ref. 41 1900-1974 - 10 hurricanes, including 3 great hurricanes. See Ref. 13 Major events: 1906, 1954 (Hazel), 1959 (Gracie), 1976 (Belle).	Rain, wind, storm surge, accelerated erosion, tornadoes. 1929 hurricane-associated flooding. $9 million damage in Georgia, South Carolina, North Carolina, & Virginia. 2000 people killed in pre-1900 storm. See Ref. 41	19.8% population increase since last major hurricane. See Ref. 13 Past experience of population may facilitate evacuation. Continued development of hazard area adds to vulnerability.	U.S. Army Corps of Engineers National Weather Service (NOAA) National Hurricane Center (NOAA) South Carolina Disaster Preparedness Agency South Carolina Water Resources Commission South Carolina Dept. of Wildlife & Marine Resources	Construction of storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Issues warnings, disseminates hurricane information. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans. Planning studies. Planning studies; policy recommendations.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	30% critically eroding, 45% noncritical, 25% stable. See Ref. 55 Especially severe in coastal inlets, Folley Beach, Hilton Head Island, Garden City Beach, Isle of Palms.	Chronic but accelerated by storms.	Undermines banks, buildings, erodes beaches, erosion, hurricane & flooding protective structures, contributes to sedimentation problems. Threat to property.	Rapidly increasing development adds to damage potential.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration South Carolina Dept. of Highways. South Carolina Dept. of Wildlife & Marine Resources	Study coastal erosion problems, plan& construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Structural protection works. Planning studies; policy recommendations.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.
Coastal Flooding	Rivers & low-lying coastal areas.	Flooding caused by hurricanes & local storms. Damages not usually major in coastal areas. Major events (before 1950): Santee River 1645, 1908; Cape Fear 1908, 1928, 1929, 1945, 1947. See Ref. 15	Marshes frequently flooded.	Current controls probably adequate to keep risk small.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration U.S. Geological Survey South Carolina Land Resources Conservation Commission South Carolina Disaster Preparedness Agency	Study coastal flood problems, plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Prepare flood-prone area maps. Planning studies; disseminates information; land use control guidelines & recommendations. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Responsible under Sec. 201 of PL 93-288.
Earthquake	Moderate damage expected on north coast. Major damage on south coast, including Charleston. See Ref. 2	Expected 19.9 modified Mercalli maximum intensity V earthquakes per 100 years. Maximum expected intensity, X. See Ref. 61	1886 Charleston intensity IX-X earthquake. See Ref. 59 60 killed, $23 million damage. Possibility of major event causing great social & economic disruption.	Relative inexperience with earthquakes may contribute to disruption should a major earthquake occur. Increasing development adds to vulnerability.	U.S. Geological Survey South Carolina Geological Survey South Carolina Disaster Preparedness Agency	Conducts geologic studies in order to monitor & possibly predict seismic activity. Technical studies of geology & soils. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

TEXAS

The Texas coastal zone includes 3,359 miles of tidal shoreline along the Gulf of Mexico (U.S. Dept. of Commerce, 1971). This shore is used intensively for recreation and industrial purposes. Nearly forty per cent (40%) of the nation's petrochemical industry and twenty-five (25%) of the nation's refining capabilities are situated along this shoreline (Texas General Land Office, 1976). The population and economy of the Texas Gulf Coast have grown rapidly over the past decade. Today nearly fifty per cent (50%) of Texas residents live within 100 miles of the coastline. Between 1960 and 1970 the coastal population grew even faster (24.8%) than that of the state as a whole (16.9%) (Moseley, 1976).

The predominant natural hazard in the Texas coastal zone is hurricane, with accompanying tornadoes, storm surge, high winds, and heavy rainfall flooding. Since 1900, total damage has exceeded $1.3 billion and 114 lives have been lost (Texas General Land Office, 1976). Although the entire coastline is vulnerable, barrier islands and coastal lowlands are the most susceptible to hurricane damage.

A second major problem on the Texas coast is erosion, the delta areas of the Brazos, Colorado, and Rio Grande rivers being the most vulnerable. Erosion is a continual process which is exacerbated by storm surges and high winds. The lack of a sufficient sand supply to maintain equilibrium is the main cause of continuous erosion of the Texas beaches.

Another hazard in the Texas coastal zone is flooding, both as a result of hurricanes, and less frequently, river runoff which may inundate coastal lowlands. Since 1961, approximately 3,164 square miles have been inundated (Brown, et al., 1974).

Subsidence of land is a hazard in the Texas coastal zone which has recently gained considerable attention. Land-surface subsidence, primarily a consequence of ground-water pumping and withdrawal that began in the Texas coastal zone early in the century, affects a substantial part of the lower Texas coastal plain. Consequences of land subsidence in coastal areas include: loss of land in low-lying tidal areas, submergence of structures, and subjection of more land to flooding, hurricane surge or stream runoff (Brown, et al., 1974).

Table IV-27 shows the nature of the natural hazards in the Texas coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing these coping measures.

Most governmental decisions affecting the Texas coastal zone are made at the local level. Most of these decisions regarding water use are subject to guidelines and regulations issued by the state. Counties have no authority and cities have home-rule powers.

Management of Texas' coastal resources is fragmented among more than a dozen independent agencies. The principal entity for the coordination of these agencies is the Interagency Council on Natural Resources and the Environment (ICNRE) established in 1967. The key disaster agency is the Division of Disaster Emergency Services in the Office of the Governor.

Several legislative tools exist in Texas which can be utilized to provide protection from coastal hazards. The Texas Open Beach Act of 1959 *as amended) prevents development of the beaches back to 200' or the vegetation line and thus reduces possibly hazardous situations (Moseley, 1976).

The Dune Protection Bill of 1973 authorizes counties to establish a regulatory procedure for dune protection, although implementation is spotty and generally weak. Only two counties have such regulations and they readily give variances (Moseley, 1976).

Present authority to deal with subsidence is shared by special purpose districts. Although underground water conservation districts may be formed to regulate water wells in order to control subsidence, none have been created, as yet, in the coastal counties. However, the Harris-Galveston Coastal Subsidence District was established by the 64th legislature to control subsidence in those two coastal counties (Texas Laws 1975, Ch. 284, at 672-684). (Texas, General Land Office, 1976).

The chief mechanism through which the state proposes to implement its coastal management program is the permitting process. Through this process, the state is able to regulate many public and private actions on the coast. At present the permit procedure is exceedingly complex and unwieldy, although the Texas Coastal Management Program (TCMP) has recently proposed measures to achieve better coordination among state agencies. Windstorm Catastrophe Pool (CATPOOL), operated by the Texas Catastrophe Property Insurance Association (TCPIA), an association of insurance companies, must provide windstorm insurance to all coastal property owners. They pool resources to do so. All companies must participate. Operation is supervised by the State Insurance Board.

NATURAL HAZARD MANAGEMENT IN THE TEXAS COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Hurricane	Entire coast exposed. Eastern coast more likely to experience a hurricane.	7-14% probability of hurricane effects in any given year. 2-5% probability of a great hurricane. See Ref. 41 1% probability of a 15 ft. storm surge near Port Arthur; 11 ft. storm surge expected near Brownsville. See Ref. 41 1900-1974 - 31 hurricanes, including 13 great hurricanes. See Ref. 13 Major events: 1900, 1915, 1919, 1932, 1961 (Carla), 1967 (Beulah), 1970 (Celia).	Rain, wind, tornadoes, storm surge, accelerated erosion. 1961 (Carla) - gusts to 175 mph; highest storm surge, 16.6 ft. above mean sea level at Port Lavaca. See Ref. 60 $408 million damage, 32 dead. See Ref. 5	52.9% population increase since last major hurricane. See Ref. 13 Inexperience of population may hinder evacuation. Rapidly increasing development of coastal areas adds to damage potential. Land subsidence increases acreage exposed to flooding.	U.S. Army Corps of Engineers National Weather Service (NOAA) Texas Office of the Governor/Division of Disaster Emergency Services-Texas Dept. of Public Safety National Hurricane Center (NOAA) Texas Coastal & Marine Council Texas Catastrophe Property Insurance Association	Construction of storm surge protection structures. Collects & disseminates meteorological information. Issues hurricane warnings. Assists in relief to local areas. Drafts & maintains a state disaster preparedness plan; coordinates local disaster plans. Issues warnings, disseminates hurricane information. Authorized by legislature to establish model minimum building standards. Disseminates hazard information, assists in marine related affairs at state, national & international levels. Designing model minimum building standards for coastal development. Provides wind storm insurance for 14 coastal counties under a pool of private insurance agencies (CATPOOL).	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Responsible under Sec. 201 of PL 93-288. S.R. 268 Catastrophe Property Insurance Act of 1971 - Texas Legislature.
Coastal Erosion	4% of coast is critically eroding, 10% noncritical erosion, 86% stable. See Ref. 54	Continual process accelerated by storms, climate, sea levels, & sediment supply.	Damages buildings, roads, beaches, dunes, protection works.	Development of coastal areas increases damage potential.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration Municipal Government County Governments	Study coastal erosion problems, plan & construct erosion control structures. 1973 Flood Protection Act provides Federal insurance against damages from accelerated erosion. Establish zoning ordinances, building codes & land use management programs. Issue sand, marl, shell & gravel permits. Applies to lands outside cities & towns within 1500 ft. of a mainland public beach.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding.

TABLE IV-27 (cont'd)

NATURAL HAZARD MANAGEMENT IN THE TEXAS COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	Estuaries, wetlands, low-lying coastal areas.	Flooding caused by hurricanes, severe storms.	Damage to buildings in flood plain, accelerated erosion. 1967 (Beulah) - fresh water flooding of 2,187 square miles, causing $98 million damage. See Ref. 5	Numerous protection works may encourage development of areas vulnerable to catastrophic losses. Susceptibility increasing with development of coast.	U.S. Army Corps of Engineers	Study coastal flooding problems, plan & construct flood control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administers NFIA & Flood Disaster Protection Program.	See Ref. 31
					Texas Water Development Board	Acts as state agency responsible for coordinating/supervising Federal Flood Insurance Program.	
					State Soil & Water Conservation Board	Administers the state's responsibility under the Federal Watershed Protection & Flood Prevention Act.	Channels money to local districts.
					County Governments	Responsible for flood plain management & dune protection.	Through taxation & special "zoning" authority for flood plains only to comply with FIA.
					Texas Office of the Governor/Division of Disaster Emergency Services-Texas Dept. of Public Safety	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					Texas Coastal & Marine Council	Disseminates hazard information; assists in marine related affairs at state, national & international levels.	
Subsidence	Primarily near Houston area; Freeport & Corpus Christi	Due to withdrawal of water from subsurface clays, which then compact & lower surface elevation.	Hazard to property estimated $30 million annually near Houston.	Increasing steadily with growth of population.	Texas Water Development Board	Conducts ground water studies & oversees creation of underground water conservation districts to control subsidence, particularly in the coastal areas.	1973 Amendments to the Texas Water Code - Sec. 52.021 of HB 935.
					Harris-Galveston Coastal Subsidence District	Created by the 64th Legislature.	Controls withdrawal of ground water within the boundaries of this 2-county district.
					Texas Water Rights Commission	Oversees the Harris-Galveston Subsidence District.	15 member board utilizes a permit system to regulate withdrawals of ground water by controlling well spacing & production.

VIRGINIA

Virginia's coastal zone including offshore islands, Chesapeake Bay and Atlantic Ocean shoreline is 3,315 miles in length (U.S. Department of Commerce, 1971). Two hundred and ninety-four (294) miles of this is classified as beach. Seventy-seven per cent (77%) of the coast is privately owned, and limited public access to the shore is a serious statewide problem . All but 106 miles of coast are either undeveloped or in non-recreational low density uses (U.S. Army Corps of Eng., 1971c).

The Chesapeake Bay shore consists of erodible bluffs interspersed with tidal wetlands and scattered sandy beaches. Uninhabited barrier islands and wetlands occupy most of the Atlantic shores of Northampton and Accomack counties. Much of this land is owned by the Nature Conservancy - an international, private, non-profit organization. Apart from the city of Virginia Beach and the small community of Sandridge, the coast between Cape Henry and the North Carolina boundary is occupied by military reservations, state park land and nature reserves.

Virginia's Tidewater counties - which are used for preliminary coastal zone planning purposes - encompass twenty-nine per cent of the state's area and include sixty-two per cent (62%) of the total population (i.e. 3,028,150). Population growth in this area is one and one half times faster than the state average. Although woodland (59.1%) and agriculture (22.4%) are the dominant land uses, residential development (3.1%) and tourism are increasingly important components (U.S. Army Corps of Eng., 1971c). Here, tourism - most of it shore based - provides sixteen per cent (16%) of all private employment in Virginia (Schmid, 1976).

looding and erosion are rated as high priority concerns by planners in coastal counties (Coastal Zone Management Regional Advisory Committee, 1976). Increasing urbanization along the southern shores of Chesapeake Bay, combined with the pending development of onshore Outer Continental Shelf (OCS) oil and gas support facilities, will exacerbate present flood and erosion problems. Storm surge flooding associated with hurricanes and slow moving hortheasters, is a major problem in Chesapeake Bay. Although there is a two per cent (2%) chance that hurricanes will affect the Virginia shore (Simpson and Lawrence, 1971) there are no public provisions - apart from post-disaster civil defense activities - for coping with or mitigating hurricane problems in the coastal zone. FIA's delimitation of additional flood hazard areas awaits completion of a storm surge research study.

Erosion is a critical problem along eighteen per cent (18%) of the shorefront (U.S. Army Corps of Eng., 1971a). The Virginia Institute of Marine Science has undertaken a comprehensive assessment of erosion and flood hazard in each coastal county. Several Shoreline Situation Reports are published each year and these will form one basis for state evaluation of shoreline development applications, requests for permits and future consturction activities.

Table IV-28 shows the nature of the natural hazards in the Virginia coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

Virginia's 1973 Erosion and Sediment Control Law requires comprehensive erosion control plans to be developed by coastal localities. The state's Wetlands Act (1972) provides coastal localities and the Virginia Marine Resources Commission with authority to issue permits for construction in flood-prone tidal wetlands and adjacent territory. Together with the flood hazard clauses of the statewide building code, these are the primary management tools for coping with flood and erosion hazards throughout the state. All coastal counties have now been required by the state to draw up comprehensive plans, together with supporting planning commissions, and building and sub-division regulations.

Since 1774, 137 earthquakes are known to have occurred in Virginia (Hopper & Bollinger, 1971-72). Approximately twenty-five per cent (25%) of these were located in coastal counties. The majority rated less than V on the modified Mercalli scale (1931) (i.e. disturbances of trees, poles and other tall objects; no substantial damage). There are no public plans for coping with earthquake or seismic hazard in the coastal zone.

It is too soon to evaluate the ability of state initiatives to mitigate natural hazards in the coastal zone. Preliminary observations suggest that the wetland permit program appears to have slowed development in some flood-prone areas. Likewise, the Virginia Beach Erosion Commission has been generally successful in retaining useable recreational beaches - although at considerable local cost. Private protection activities are generally unsuccessful in the long run.

TABLE IV-28

NATURAL HAZARD MANAGEMENT IN THE VIRGINIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	Wetlands & adjacent low-lying shores of Chesapeake Bay & Atlantic.	Flooding caused by hurricanes, local storms, north-easters. 4 major floods 1900-1950. See Ref. 15	Inundation of flood plain, damage to structures. Mar. 1962 storm inundated Chincoteague; estimated $7.1 million damage. See Ref. 6 7.8 ft. storm surge in Hampton. See Ref. 13	Wetland permit program may have slowed development in flood plain. Increasing development will increase vulnerability.	Office of the Governor/Office of Emergency Services	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
					U.S. Army Corps of Engineers	Study coastal flood problems, plan & construct flood protection structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	Administers NFIA & Flood Disaster Protection Act.	See Ref. 31
			Aug. 1933 hurricane: 7.0 ft. storm surge in Baltimore.		Virginia State Water Control Board	State coordination agency for NFIP. Contracts with Corps of Engineers & USGS for flood insurance studies, review agency for flood protection projects in Virginia.	Virginia Beach, Hamptons & Portsmouth in regional program
					Virginia Marine Resources Commission	Administers permit program under Virginia Wetlands Act (1972).	Affects areas 1.5 times the tidal range above mean low water as modified to include vegetation species named in the act. Permit applications are also reviewed by the Virginia Institute of Marine Sciences.
						Sections 62.1-2 through 62.1-30 of the Virginia Code empower the Marine Resources Commission to regulate the beds of bays, rivers, streams, & creeks in state ownership.	
					Virginia Office of Commerce & Resources (Incorporates former State Planning Office)	Currently designating Geographical Areas of Particular Concern (GAPC) for Federal Coastal Zone Management program.	See Ref. 67
					Virginia Planning Districts	Comprehensive land use planning.	Mainly advisory on hazard problems.
					Local Governments	Must adopt flood plain management ordinances including land use controls.	Must meet state minimum standards - all new buildings must locate their basement or first floor at or above the 100 year flood level. Also must meet FIA approval. State Water Control Board cannot intervene.

TABLE IV-28 (cont'd)

NATURAL HAZARD MANAGMENT IN THE VIRGINIA COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Of shore 26% critically eroding, 30% noncritical, 44% stable. See Ref. 53 Most affected: barrier islands, bluffs on west shore of Chesapeake, Virginia Beach, lower Potomac River shores.	Accelerated by storms, high water, subsidence. 1852-1962 Wreck Island averaged 34 ft. per year loss. See Ref. 65 17 square miles lost from barrier islands. See Ref. 66	Damages structures, protective works, beaches, etc. Erosion & sedimentation threatens ecosystems & navigation. Estimated cost of beach restoration & maintenance for Virginia coast: $1,135 million. See Ref. 56	Damage potential increasing as Virginia attracts more investment, especially summer homes & off-shore oil & gas activities.	U.S. Army Corps of Engineers	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Administration	1973 Flood Protection Act provides federal insurance against damages from accelerated erosion.	Coverage limits are the same as for coastal flooding.
					Virginia Soil & Water Conservation Commission	1973 Erosion & Sediment Control Law gave Commission responsibility for coordinating all shore erosion activity in Virginia. Provides for a comprehensive statewide control program.	Must meet minimum state standards which exist, but are generally not enforced.
					Virginia Office of Commerce & Resources	Currently designating Geographical Areas of Particular Concern (GAPC) for Federal Coastal Zone Management program.	See Ref. 67
					Virginia Marine Resources Commission	Administers permit program under Virginia Wetlands Act (1972).	
					Virginia Planning Districts	Comprehensive land use planning.	Mainly advisory on hazard problems.
					Virginia Beach Erosion Commission	State institution appointed by the governor to preserve waterfront in the Virginia Beach area. Funded by municipal "sand tax."	Beach nourishment, construction of structural protection devices, & beach stabilization research.
					Local Governments	Beach nourishment programs, structural protection devices.	No general requirement to adopt shore erosion ordinances or setback lines.
Hurricane	Barrier islands most vulnerable; entire coast exposed.	2% probability of hurricane effects, 1% probability of a great hurricane. See Ref. 41 4 hurricanes, including 1 great hurricane, 1950-1975. See Ref. 13 Major events - 1944, 1960 (Donna).	Rain, storm surge, wind tornadoes, accelerated erosion. 1929 hurricane-related flooding - $9 million damage in Georgia, South Carolina, North Carolina, Virginia. See Ref. 15	98.5% population increase since last major hurricane. See Ref. 13 Inexperience of population may hinder evacuation. Continued development of coast adds to vulnerability. Construction of off-shore oil & gas facilities will increase industrial risk.	U.S. Army Corps of Engineers	Construction of storm surge protection structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					National Weather Service (NOAA)	Collects & disseminates meteorological information; issues hurricane warnings.	Maps prepared for Norfolk & areas bordering Chesapeake Bay.
					U.S. Geological Survey	Prepares flood-prone area maps.	
					National Hurricane Center (NOAA)	Issues warnings, disseminates hurricane information.	
Earthquake	Minor damage expected along coast.	Approximately 35 earthquakes of intensity V or less (modified Mercalli) have occurred in coastal counties since 1774. See Ref. 14	Trees, poles & tall objects disturbed; no major damage.	Little increase in vulnerability.	U.S. Geological Survey	Conducts geologic studies in order to monitor & possibly predict seismic activity.	
					Virginia Division of Mineral Resources	Technical studies of geology & soils.	
					Office of the Governor/Office of Emergency Services	Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.

The State of Washington's coastal zone contains 2,337 miles of marine shoreline and includes parts of fifteen of the state's thirty-nine counties, containing two-thirds of the state's population. The marine shoreline is distributed as follows: 157 miles along the Pacific Ocean, 218 miles in the Grays Harbor and Willapa Bay estuaries on the coast, 144 miles along the Strait of Juan de Fuca, thirty-four miles on the Columbia River, and 1,784 miles bordering Puget Sound and the Strait of Beorgia to the north, including the San Juan Island archipelago (State of Washington, 1976).

The coastal zone of Washington is vulnerable to a variety of natural hazards: earthquakes, landslides, coastal erosion, coastal flooding and tsunamis.

In 1949 an earthquake, registering 7 on the Richter scale, caused $25 million in damage, and in 1965 Seattle was jolted by a moderate quake (6.5 R) which resulted in $12.5 million in damages.

Landslides and accelerated coastal erosion are frequently triggered by such seismic disturbances. Eighty to ninety per cent (80-90%) of Washington's coastal zone is subject to landsliding and erosion. The high bluffs, which comprise much of Washington's shoreline, are often unstable due to their composition of loosely consolidated and heterogeneous glacial material. Seismic disturbances, increased human impact, devegetation, over-building, and heavy precipitation all contribute to the landslide hazard. The erosion of beaches and dunes, a continuous process, is exacerbated during periods of wind, high tides, and storms.

Another hazard along the Washington coast is flooding; the combination of heavy precipitation and stream flow with high tides and strong on-shore winds poses recurrent flood problems for the low-lying coastal areas of Washington. Upstream diking and channelization have increased the problem by deliving runoff more rapidly to the coastal zone. In December 1975, severe coastal flooding cuased the failure of a dike and resulted in serious damage to coastal estuaries and heavy losses to property and livestock.

Tsunamis are infrequent hazards along the entire Washington shoreline, including Puget Sound, but have the potential to cause serious coastal flooding. In 1964, tsunami waves generated by the Alaskan earthquake destroyed two bridges and stranded numerous residents and recreators along the southern Washington coast.

There are five dormant, but not extent, volcanoes in Washington State. Three of these volcanoes, Mt. Rainier, Mt. Baker, and Glacier Peak, could have an effect on the coastal environment given certain eruptive characteristics, glacier melt-off conditions, and wind directions. Rapid glacier melt-off due to volcanic heating could cause flooding and/or mud flows along rivers draining volcanic areas. Flooding, mud flows, or water borne ash could seriously affect coastal areas. It is also possible for wind carried ash from volcanic eruptions to affect part of the Puget Sound coastline.

Table IV-29 shows the nature of the natural hazards in the Washington coastal zone, the measures for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The planning program and permit system developed by local jurisdictions in response to the Shoreline Management Act of 1971, is the cornerstone of hazards management in Washington. The Washington Coastal Zone Management Program of 1976, the first to gain Federal approval, is based largely upon the 1971 Act. Under this plan, each local government is to prepare a comprehensive shoreline inventory and a master program for the regulation of shoreline uses. The entire planning effort is conducted in conformance with guidelines prepared and adopted by the Department of Ecology, the agency responsible for administration of both the Shoreland Management Act and the new Coastal Zone Management Program. The resulting local programs are subject to state review and approval, and adoption. The regulatory permit system is overseen by a state administrative appellate body.

TABLE IV-29

NATURAL HAZARD MANAGEMENT IN THE WASHINGTON COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Earthquake	Moderate damage expected for most of state. See Ref. 61 Built-up land: Harbor Island, Duwamish in Seattle & Port of Tacoma could suffer liquefaction & subsidence.	80.1 modified Mercalli maximum intensity V earthquakes expected per 100 years. Maximum intensity expected is VI (VIII expected in Seattle area). 41 earthquakes modified Mercalli VI or greater, 1841-1970. See Ref. 59	Earthquake may trigger landslides, avalanches, tsunami, fire & submarine slides. 1949 Olympia earthquake - 8 dead, $25 million damage, Richter = 7.0. 1965 Seattle earthquake - 7 killed, $12.5 million damage, Richter = 6.5. Followed same damage patterns as 1949 earthquake.	Increasing development increases susceptibility to a major earthquake.	U.S. Geological Survey Washington Dept. of Emergency Services	Conducts geological studies in order to monitor & possibly predict seismic activity. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Landslide	Major severity along coast. See Ref. 43 North coast & inland shores most susceptible See Ref. 62	Materials involved include rock, debris, & soil moving in a fall, slide, or flow. May be triggered by coastal erosion, earthquakes, man's activities, rain.	Concentrated effects unless regional transportation or utility route is disrupted.	Increasing with expanding development, especially residential. Transportation arteries are also vulnerable.	U.S. Geological Survey Washington Dept. of Emergency Services	Research in landslide prediction through the Landslide Hazard Reduction Program. Draft & maintain a state disaster preparedness plan; coordinate local disaster plans.	Responsible under Sec. 201 of PL 93-288.
Coastal Erosion	Of ocean exposure: 1% critically eroding, 11% noncritical erosion, 88% stable. Bay & estuary shores are less vulnerable. Most critical erosion in Clallam, Pacific, Grays Harbor, & Pierce Counties. See Ref. 50	Continual process accelerated by storms, especially in winter.	Damages buildings, roads, beaches, bluffs, dunes, etc. Cape Shoalwater, Pacific County, cost to stabilize 3 miles: $30-100 million. (No guarantee of success.) Cost of buying endangered land & moving buildings in area: $3 million. See Ref. 50 Toke Point, Pacific County: average loss of 12 feet/year past 50 years. 17 city blocks lost. Population of 700 - area declining due to erosion. See Ref. 50	Increasing slowly with increased development in both urban and nonurban areas.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration State & Local Highway Depts. Railroads Local Governments Washington Dept. of Ecology/County Officials	Study coastal erosion problems; plan & construct erosion control structures. 1973 Flood Protection Act provides federal insurance against damages from accelerated erosion. Design & location of roads. Control of rights-of-way. Planning, zoning, building, & subdivision control. *Implement Shoreline Management plans* & policies, & related legislative mandates.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). Coverage limits are the same as for coastal flooding. Need increased recognition of geologic problems. Maintain bluff stability along rights-of-way. The Shoreline Management plans & permit systems apply only to new developments; no retroactive authority.

NATURAL HAZARD MANAGMENT IN THE WASHINGTON COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Flooding	All estuaries & stream valleys along entire shoreline. Low-lying areas vulnerable to storm waves.	Winter & spring flooding caused by snow melt &/or rain. Damaging events estimated at 1 in 5 years, or 1 in 20 years on streams with flood control projects.	Heavy property damage. Effects may be compounded by high tides & bursting of temporary dams. Dec. 1933 - extensive flooding caused $18 million damage. Jan. 1935 - 4 dead, $1.5 million damage, Wynoochee & Queets Rivers at record flood state. Previous 24 hr. & 5 day precipitation records broken. Dec. 1975 - serious flooding of Nooksack, Skagit, Snohomish, Nisqally, & Grays Harbor estuaries. Sudden failure of dike resulted in heavy losses of livestock. See Ref. 13	Increasing at a decreasing rate under Shoreline Management implementation. Protective works on Columbia reduce average losses.	U.S. Army Corps of Engineers U.S. Federal Insurance Administration U.S. Geological Survey Local Governments	Study coastal flood problems; plan & construct flood control structures. Administer NFIA & Flood Disaster Protection Act. Prepare flood-prone area maps. Flood hazard guidelines under Shoreline Management program; must adopt flood plain management ordinances, including land use controls meeting state minimum standards for all lands subject to flooding by 100 year recurrence interval floods.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975). See Ref. 31 Shoreline Management guidelines assign low density classifications to the 1/100 year flood recurrence.
Tsunami	Entire coastal area exposed except for sheltered bays. Low-lying areas most vulnerable. Slight possibility in Strait of Juan de Fuca.	Impulsive disturbance in ocean generates a series of long waves which build in height as approach shore. Estimated frequency, 1 in 100 years. Partial evacuations in 1952, 1963, 1964, 1965.	1964 Alaska earthquake triggered tsunami. Only tsunami to hit Washington in last 25 years. No loss of life, partly due to successful warnings. 2 bridges destroyed. Origin of tsunami, configuration of coast, magnitude, & extent of development contribute to damage potential. High catastrophe potential.	Inadequate preparedness & lack of experience with tsunamis contribute to damage potential. Increasing with more recreational activity & coastal development.	National Weather Service (NOAA) U.S. Federal Insurance Administration Washington Dept. of Emergency Services Local Governments	Collects & disseminates meteorological information; issues tsunami warnings. Hazard area designation; assist local communities with eligibility for insurance. Draft & maintain a state disaster preparedness plan; coordinate disaster management. Issue warnings, engage in evacuation planning & traffic control.	Responsible under Sec. 201 of PL 93-288.
Volcano	Mt. Baker, Mt. Rainier Glacier Peak.	Dormant, but not extinct.	Rapid glacier melt-off due to volcanic heating. Could cause flooding &/or mud flows affecting the coastal area & Puget Sound coastline.	Mt. Baker currently undergoing activity.	U.S. Geological Survey U.S. Forest Service Washington Dept. of Emergency Services Local Governments	Monitors volcanic activity & stream pH in areas draining the crater Regulates visitor use of volcanic areas. Coordinates disaster management & relief efforts of all state agencies, & serves as intermediary between Federal disaster relief agencies & local governments. Issue warnings & direct evacuation.	Responsible under Sec. 201 of PL 93-288.

WISCONSIN

Wisconsin's coastal zone includes approximately 620 miles of shoreline, touching on fifteen counties which have a population of two million people. Of the 620 miles of shoreline, just less than half, or 299 miles, have a beach zone.

Coastal erosion and flooding are chronic problems in the Wisconsin coastal zone. Almost one quarter of the coastline, about 150 miles, is subject to critical erosion, 250 miles are subject to non-critical erosion, and eighty-six miles are subject to flooding. The remainder, approximately 134 miles, are considered non-eroding, stable or protected (Miller, 1976).

Both flooding and critical erosion are exacerbated during periods of high water. During the high water period, 1951-52, combined losses from flooding and erosion amounted to about $6 million along the Wisconsin shoreline (U.S. Army Corps of Eng., 1971a). Damage figures from the more recent 1971-72 high-water period are not available.

Table IV-30 shows the nature of the natural hazards in the Wisconsin coastal zone, the measures available for coping with those hazards, and the locus of authority and responsibility for employing those coping measures.

The 1965 Water Resources Act, as subsequently amended, is the cornerstone of natural hazard management under the Wisconsin Coastal Management Development Program. The flood plain zoning provisions of that Act lodge responsibility in municipalities and counties for protection of riverine areas, subject to state guidelines. To date, 186 counties, cities, and villages are covered by state-approved regulations, considerably less than the 1968 goal of full coverage stipulated by the 1965 Act. The State has elected to educate, persuade, and assist local governments to comply, a slow process at best.

The shoreland zoning provisions of the Water Resources Act apply only to land outside of incorporated areas and lodge responsibility in the counties. All counties have enacted regulations. Erosion control is not a named justification or purpose for shoreland zoning under the Act, although legal opinion within the Department of Natural Resources holds it to be an implied purpose. Consequently, erosion control is not yet a major feature of existing county shoreland regulations.

TABLE IV-30

NATURAL HAZARD MANAGEMENT IN THE WISCONSIN COASTAL ZONE

HAZARD	LOCATION OF VULNERABLE AREAS	CHARACTER AND FREQUENCY OF EXTREME EVENTS	EFFECTS	FUTURE SUSCEPTIBILITY	RESPONSIBLE AGENCIES	LEGISLATIVE AUTHORITIES INSTITUTIONAL ARRANGEMENTS	ADMINISTRATIVE RELATIONS AND POLICIES
Coastal Erosion	Critical shore-line erosion problems exist at several locations: a large part of the Wisc. L. Superior red clay bluffs are subject to critical erosion. 6% of shore is critically eroding, 40% noncritical erosion, 54% stable. See Ref. 51	Coastal erosion is a continuous problem which is accelerated during periods of high lake levels. Such periods occurred during the late 1920's, mid-1940's, early 1950's and early 1970's. Erosion may also become accelerated as a result of winter storms and seiche conditions during high water periods.	Extensive erosion along the L. Michigan shoreline between the Sheboygon-Ozaukee County line occurred during 1951-52 and resulted in nearly $3 million in damages & losses to public beaches and private property. See Ref. 51	Increasing where development continues along shoreline & as property values climb.	International Joint Commission/Great Lakes Levels Board	Control of water levels in the Great Lakes	See Ref. 56 (Minnesota)
					U.S. Army Corps of Engineers,	Study coastal erosion problems, plan & construct erosion control structures.	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					Wisconsin Dept. of Natural Resources	Conducts & formulates plans, studies, & policies for shoreland management. Prepares & provides to municipalities standards & criteria (1) for studies & planning, and (2) for protection regulations and their administration. Adopts shoreland management regulations where counties do not do so.	Shoreland defined as lands within 1000 ft. of a lake, pond, or flowage or within 300 ft. of a river or stream, or to the landward side of a flood plain, whichever is greater. Setback of 75 ft. required, except where other development already exists.
					Local Government	Counties must adopt suitable shore-line ordinances. Municipalities may do so. Counties not complying must pay costs of DNR in preparing regulations.	
Coastal Flooding	Shorelands between Marinette Harbor and east city limits of Green Bay are susceptible to flooding.	Periods of extreme high water are a chronic problem & have occurred during this century in the late 1920's, mid 1940's, early 1950's and most recently in the early 1970's. Periods of high water accompanied by winter storms & high winds have caused serious coastal flooding.	April 13, 1952 Combination of high water & storm winds raised water level 2 ft. above normal. Water overflowed the low-lying shore of the Fox River & flooded 1800 acres of the City of Green Bay causing $1/2 million in damages. April 1973 event had significant damage, $4,188,300. See Ref. 51	Zoning and setback ordinances of the Wisconsin Shoreland Protection Ordinance of 1965 will help to prevent future losses to new structures within the coastal zone but will have a limited effect on reducing damage to pre-existing structures & natural features. See Ref. 51	International Joint Commission	Control of water levels in the Great Lakes	See Ref. 56 (Minnesota)
					U.S. Army Corps of Engineers	Study flood problems, plan and construct flood control	U.S.C.S. Sec. 701 a-1, n, s (1960), as amended, (Supp. 1975).
					U.S. Federal Insurance Admin:	Delineate flood hazard areas, administer flood insurance program	See Ref. 31
					Wisconsin Department of Natural Resources	Assist local governments in preparing flood plain regulations, establish flood plain regulations when local governments do not do so, charge local governments for the costs of establishing such regulations. See Ref. 64	Flood plains defined as land subject to inundation by flood of 100 year recurrence interval.
					Local governments	Must delineate flood plains, & adopt & enforce effective flood plain regulations. May employ zoning subdivision controls, building codes, etc., as regulatory measures. Must enforce any regulations adopted by the State.	

REFERENCES

1. Alaska Department of Environmental Conservation, Coastal Processes, Terrain, and Hazards. ADEC, Division of Water Programs, Environmental Analysis Section, 1976.

2. Ayre, Robert S., Earthquake and Tsunami Hazards in the U.S.: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, 1975.

3. Beaulieu, John D., et al., Geologic Hazards Inventory of the Oregon Coastal Zone. Oregon Department of Geology and Mineral Industries, Miscellaneous Paper 17, 1974.

4. Bell, Eloise, Environmental Planning Consultant, North Carolina Coastal Resources Commission, Personal Communication with Gilbert F. White. Oct. 22, 1976.

5. Brown, L. F., Jr., R. A. Morton, J. H. McGowen, C. W. Kreitler, and W. Fisher, "Natural Hazards of the Texas Coastal Zone." University of Texas, Austin, Bureau of Economic Geology, 1974.

6. Burton, Ian, Robert Kates & Rodman Snead, The Human Ecology of the Coastal Flood Hazard in Megalopolis. University of Chicago, Department of Geography Research Paper No. 115, 1969.

7. California Coastal Zone Conservation Commission, California Coastal Plan. San Francisco, December 1975.

8. Coastal Zone Management Regional Advisory Committees in Virginia Planning Districts, "Coastal Resources Planning and Management Problems and Issues in Virginia." Unpublished report compiled from CZM Regional Assessment Reports, Richmond, Virginia, 1976.

9. Delaware State Planning Office, News. Vol. 1, No. 2, Sept/Oct 1975.

10. Delaware State Planning Office, Delaware's Changing Shoreline: Kent County and Northeast Sussex County, Dover, April 1976.

11. Ervin, Timothy P., Assistant Planner, Michigan Department of Natural Resources, Personal communication with Gilbert F. White, Oct. 15, 1976.

12. Great Lakes Research Institute, Identification and Analysis of Lake Erie Coastal Hazards Areas. Report to Pennsylvania Department of Environmental Resources, Erie, Pennsylvania, 1975.

13. Hebert, Paul J. and Glenn Taylor, Hurricane Experience Levels of Coastal County Populations, Texas to Maine. U.S. Department of Commerce, NOAA, National Weather Service, July 1975.

14. Hopper, Margaret G. and G. A. Bollinger, The Earthquake History of Virginia (2 parts). Blacksburg: Department of Geological Sciences, Virginia Polytechnic Institute and State University, 1971-72.

15. Hoyt, William G. and Walter B. Langbein, Floods. Princeton, New Jersey: Princeton University Press, 1955.

16. Lauricella vs. Planning and Zoning Board of Town of Greenwich, 342 A.2d 374, 1974.

17. Maryland Department of Natural Resources, Summary Table in Historical Shoreline Maps Series A, Annapolis, Maryland.

18. Maryland Department of Natural Resources, Energy and Coastal Zone Administration, Coastal Zone Unit, Maryland Coastal Zone Management Authorities and Administrative Structure. August, 1976.

19. Maryland Department of State Planning, Regulating Flood-Prone Land in Maryland. May 1975.

20. Maryland Department of State Planning, Summary of Flood-Related Studies in Maryland. Publication 210, 1974.

21. Maryland, State of, Disaster Assistance Plan, Maryland Civil Defense and Disaster Preparedness Agency, Annapolis, September 1975.

22. McPherson, Bruce E., Supervisor Shoreland Management Unit, Ohio Department of Natural Resources, Personal communication with Gilbert F. White, Oct. 20, 1976.

23. Michigan Department of Natural Resources, A Plan for Michigan's Shorelands, August, 1973.

24. Michigan Department of Natural Resources, Flooding Problems Associated with Current High Levels of the Great Lakes. Water Development Services Division, December, 1973a.

25. Michigan Department of State Police, Hazard Analysis, Michigan. 2nd edition. Emergency Services Division, May 1974.

26. Michigan Department of State Police, Michigan Disaster Preparedness Program Work Plan, revised April 12, 1976.

27. Miller, Allen H., Program Administrator, Wisconsin Coastal Management Development Program. Personal communication with William B. Lord, September 2, 1976.

28. Mississippi, State of, The Governor's Emergency Council, The Mississippi Gulf Coast Comprehensive Development After Camille. 1970.

29. Mitchell, James K., Community Response to Coastal Erosion. Department of Geography Research Paper No. 156. Chicago: University of Chicago, 1974.

30. Moseley, Joseph. Coastal Marine Council. Personal communication to Gilbert F. White, Oct. 15, 1976.

31. National Flood Insurance Association, The National Flood Insurance Program Flood Insurance Manual. Arlington, Virginia: 1975.

32. New Jersey Almanac, 1966-1967 (p. 97).

33. New York State Department of Environmental Conservation and New York State Office of Planning Services, Model Zoning Ordinances for Flood Hazard Areas, 1974.

34. North Atlantic Regional Water Resources Study Coordinating Committee, NARWRS, May, 1972.

35. Oregon Department of Geology and Mineral Industries, Environmental Geology of the Coastal Region of Tillamook and Clatsop Counties, Oregon. Bulletin 74, 1972.

36. Palm, Daniel J. Lake Ontario and the St. Lawrence River: Analysis of and Recommendations Concerning High Water Levels. St. Lawrence - Eastern Ontario Commission, Watertown, New York, March 1975.

37. Saint Lawrence - Eastern Ontario Commission, Engineering Studies for a Contract for Field Investigations of High Water Damage in Oswego County, New York, Daniel J. Palm, Project Leader, Watertown, New York, 1976.

38. Schmied, Ronald Lee, Coastal Zone Advisory Specialist, Virginia Institute of Marine Science, Gloucester Point, Virginia, Personal communication with J. Kenneth Mitchell, Sept. 22, 1976.

39. Schoop, E. Jack, Chief Planner, California Coastal Zone Conservation Commission, Personal communication with William B. Lord, Nov. 8, 1976.

40. Scott, Stanley, Governing California's Coast. Institute of Governmental Studies, University of California, Berkeley, 1975.

41. Simpson, R. H. and M. B. Lawrence, Atlantic Hurricane Frequencies Along the U.S. Coastline. NOAA Technical Memorandum #NWS SR 58, U.S. Dept. of Commerce, Washington, D.C., 1971.

42. Singewald, J. T., and T. H. Slaughter, Shore Erosion in Tidewater Maryland. Department of Geology, Mines and Water Resources, State of Maryland, Bulletin No. 6, 1949.

43. Sorensen, John H., N. J. Ericksen and D. S. Mileti, Landslide Hazard in the U.S.: A Research Assessment. University of Colorado, Boulder, 1975.

44. Sorensen, John H., with J.K. Mitchell, Coastal Erosion Hazard in the U.S.: A Research Assessment. University of Colorado, Boulder, 1975.

45. Staff Members, Assessment of Research on Natural Hazards, Snow Avalanche in the United States: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, 1975.

46. Texas General Land Office, Texas Coastal Management Program. (Hearing Draft) June 1976.

47. Tyson, W.E., St. Lawrence - Eastern Ontario Commission. Personal communication with Gilbert F. White, Oct. 25, 1976.

48. U.S. Army Corps of Engineers, Alaska Regional Inventory Report, National Shoreline Study. Washington, D.C., August 1973.

49. U.S. Army Corps of Engineers, California Regional Inventory Report, National Shoreline Study. Washington, D.C., 1973b .

50. U.S. Army Corps of Engineers, Columbia-North Pacific Region, Inventory Report, National Shoreline Study. Washington, D.C., August 1971b.

51. U.S. Army Corps of Engineers, Great Lakes Regional Inventory Report, National Shoreline Study. Washington, D.C., August 1971a.

52. U.S. Army Corps of Engineers, Hawaii Regional Inventory Report, National Shoreline Study. Washington, D.C., 1973c.

53. U.S. Army Corps of Engineers, North Atlantic Regional Inventory Report, National Shoreline Study. New York, 1971c.

54. U.S. Army Corps of Engineers, Report on the National Shoreline Study. Washington, D.C., August 1971.

55. U.S. Army Corps of Engineers, South Atlantic Regional Inventory Report, National Shoreline Study. Washington, D.C., 1973a.

56. U.S. Army Corps of Engineers, State Water Resources Development Report, 1975. (Individual reports for each state.)

57. U.S. Department of Commerce, Bureau of the Census, 1970 Census of the United States. Washington, D.C.: U.S. Government Printing Office, 1972.

58. U.S. Department of Commerce, National Oceanic & Atmospheric Administration, The Coastline of the United States. Washington, D.C.: U.S. Government Printing Office, 1971 (from 4th edition, April 1, 1961).

59. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Earthquake History of the United States. Publication 41-1, Revised Edition (through 1970), Washington, D.C., 1973.

60. U.S. Department of Commerce, Weather Bureau, The Climate of Texas and the Adjacent Coastal Waters, by Robert D. Orton. Washington, D.C.: U.S. Government Printing Office, 1964.

61. U.S. Geological Survey, A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States, by Algermissen, S.T., and David M. Perkins. Open File Report 76-416, 1976.

62. U.S. Geological Survey, Preliminary Landslide Overview Map of the Conterminous United States, by Radbruch-Hall, D.H., et al., 1976.

63. USGS and NOAA, Joint Report, U.S. Army Engineer District, Baltimore, Tropical Storm Agnes - June 1972, prepared by Gannet, Fleming, Corddry and Carpenter. Harrisburg, Pennsylvania, November 1974. James F. Bailey, J.F. Patterson, J.L.H. Paulhus, Hurricane Agnes Rainfall and Floods, June-July 1972.

64. U.S. Water Resources Council, Regulation of Flood Hazard Areas. Washington, D.C.: U.S. Government Printing Office, 1971.

65. Urban Pathfinders, Inc., Brown and Root Industrial Site, Northhampton Background Study, 1975.

66. Virginia, Governor's Council on the Environment, Report of the Task Force on Erosion and Sedimentation Control. Prepared by the Erosion and Sedimentation Control Task Force, 1971.

67. Virginia Office of Commerce and Resources, Selection Criteria for Geographical Areas of Particular Concern, Draft Document, 1976.

68. Warrick, Richard A., Volcano Hazard in the U.S.: A Research Assessment. University of Colorado, Boulder, 1975.

69. Washington, State of, Washington State Coastal Zone Management Program. Department of Ecology, June 1976.

70. Wise, Peter L., Coordinator Lake Michigan Management Section, Illinois Dept. of Transportation, Personal communication to Gilbert F. White, October 20, 1976.

SECTION V

ANNOTATED BIBLIOGRAPHY

V. ANNOTATED BIBLIOGRAPHY

Alaska Department of Environmental Conservation, Division of Water Programs, Environmental Analysis Section, Coastal Processes, Terrain, and Hazards. Juneau, Alaska: 1976, 31 pp. plus maps.

Preliminary, but contains useful community-specific hazard inventory information presented cartographically in convenient form, scale 1:63,360, approximately 150 detailed maps, 5 pages of bibliographic references, and several general maps.

Anderson, William A., "Tsunami Warning in Crescent City, California and Hilo, Hawaii." In: The Great Alaska Earthquake of 1964: Human Ecology. National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake, Washington, D.C.: 1970, 116-124.

Compares a total of four tsunami warnings, the first resulting in a disaster and the second in slight wave damage, for both communities. Focuses upon the decision-making role of the local official and the warning system he has to work with.

Arctic Environmental Information and Data Center, Alaska Regional Profiles. In cooperation with Alaska Coastal Management Program, Anchorage, Alaska: 1974.

Compilation of regional geographic and geologic information, with many maps, tables, and illustrations plus extensive text.

Arctic Environmental Information and Data Center, Kadyak, A Background for Living, by Eugene H. Buck, et al. Anchorage, Alaska: 1975.

Similar to Alaska Regional Profiles in content and scope. Geographic and geologic information both on the Kodiak Island group specifically, and on Alaskan geologic problems in general. Text, photos, tables, and maps.

Arya, A. S., "Earthquake Resistant Construction in Low Cost Buildings." In: Proceedings of the International Symposium on Low Cost Housing Problems Related to Urban Renewal and Development, October 8-9, 1970, edited by Oktay Ural, Department of Civil Engineering, University of Missouri, Rolla, Missouri, 7 pp.

A review of the behavior of various kinds of construction in earthquakes, including damage charts for reinforced and unreinforced brick masonry, wooden frame with and without fill, and adobe construction. Discusses the effects of providing small amounts of reinforcement to "feebly suitable" buildings, the effect of foundation soil on structural behavior, and details of construction which effect earthquake resistance.

Ayre, Robert S., Earthquake and Tsunami Hazards in the United States: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, Co.: 1975, 150 pp.

From NSF/RANN funded assessment of research on natural hazards. A summary of the earthquake and tsunami hazards, mostly from a non-technical point of view. Includes discussion of dimensions of the hazards, simulations and scenario approaches, adjustments, and research recommendations. 176 references.

Baker, Earl J., Toward an Evaluation of Policy Alternatives Governing Hazard-Zone Land Uses. Natural Hazard Research Working Paper 28, Institute of Behavioral Science, January, 1976, 73 pp.

Paper attempts to answer the question, "What are effective ways for local planners to treat advantages and disadvantages of policy alternatives which would regulate the incidence of highly loss prone activities in the hazard zone?" Includes: a review of the types of benefits, costs and considerations to be dealt with in hazard zone management; summaries and evaluations of the land use management models of Whipple, TRW Systems Groups, Day, and James; an alternative model; and an illustrative example applied to a hurricane storm surge hazard zone.

Baker, E. J. and J. G. McPhee, Land Use Management and Regulation in Hazardous Areas: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder: 1975, 124 pp.

Discusses numerous issues involving regulation of hazardous areas: delimitation and mapping, political considerations, environmental considerations, economic factors, legal considerations, techniques for regulation, social forces and interaction of adjustments. 100 references.

Baram, Michael S., Environmental Law and the Siting of Facilities: Issues in Land Use and Coastal Zone Management. Cambridge, Massachusetts: Ballinger Publishing Company, 1976, 255 pp.

Discusses laws and regulations governing coastal zone siting of facilities. Also included, but not as extensively are methods of assessing the "national interest" and coastal zone planning in Maine. The discussion does not cover the social issues in coastal development to any significant level.

Barton, Allen H., Communities in Disaster. New York: Doubleday, 1969, 344 pp.

An expansion of a previous (1963) publication by Barton, this is a review and synthesis of disaster research, excluding warning systems and pre-disaster behavior. It contains similar material and organization as the publication on which it is based, but unlike the first, this study also includes some psychological topics such as the victims' willingness to communicate, sympathetic identification with the victim, and blaming the victim.

Barton, Allen H., "The Emergency Social System." In: Man and Society in Disaster, edited by George W. Baker and Dwight W. Chapman. New York: Basic Books, 1962, 222-267.

A description and analysis of the emergency social system at the mass and organizational level based on disaster research. Covers: 1) factors influencing the adequacy of mass and organizational response, 2) factors influencing the quantity of the mass assault relative to need, 3) factors influencing organizational mobilization, 4) coordination within and between organizations, 5) the relationships between organizational and mass behavior, and 6) methods for increasing the output of the emergency system.

Bates, F. L., C. W. Fogleman, V. J. Parenton, R. H. Pittman and G. S. Tracy, The Social and Psychological Consequences of a Natural Disaster: A Longitudinal Study of Hurricane Audrey. Disaster Study No. 18, National Academy of Sciences, National Research Council, Washington, D.C.: 1963, 190 pp.

A field study conducted over a period of 4-1/2 years from the date of the hurricane, with emphasis on long-term social change. Topics covered include: 1) warning, impact, and rescue, 2) rehabilitation and recovery, 3) role stresses associated with rehabilitation, 4) mental health effects of Hurricane Audrey, 5) social change in response to Hurricane Audrey, 6) civil defense in Hurricanes Audrey and Carla, and 7) conclusions and recommendations for further research.

Beuchert, Edward W., A Legal View of the Floodplain. Harvard Law School, Cambridge, Massachusetts: 1961, 81 pp. Reproduced by the TVA.

Briefly traces the history of channel encroachment and flood plain zoning laws. Drafts and comments on model legislation for each.

___________, "State Regulation of Channel Encroachments." Natural Resources Journal 4, (January, 1965), 486-521.

Presents an analysis of the 1965 state of the law on channel encroachment. A model floodway encroachment act is proposed.

Bish, Robert L., Robert Warren, Louis F. Weschler, James A. Crutchfield, and Peter Harrison, Coastal Resource Use: Decisions on Puget Sound. Seattle and London: University of Washington Press, 1975, 206 pp.

Essentially a regional study of coastal zone decision making. Includes: detailed background information on the region's natural, social and institutional characteristics; description of the economic, administrative and legal resource allocation processes; four case histories; an overview of Washington's Shoreline Management Act (1971); and an assessment of future management options. The lack of generalizations to coastal decision making in other regions is the volume's major flaw.

Blum, Richard H. and Bertrand Klass, A Study of Public Response to Disaster Warnings. Stanford Research Institute, Menlo Park, California: 1956, 174 pp.

Compares responses to evacuation warnings in three cities. Interviews, the analysis of weather records and reports, content analysis of media releases and subjective written accounts were used. The factors of the different community situations, source of warnings received, belief in the warnings, verification behavior, perception and subsequent evaluation of the situation, and other influences on the decision to evacuate are investigated. Appendices include: the questionnaires, a summary of press releases, tabulation and cross tabulation of responses, written accounts of personal reactions, and tabulation of responses to the second flood threat.

Bowden, Gerald, "Legal Battles on the California Coast: A Review of the Rules." Coastal Zone Management Journal, Vol. 2, No. 3 (1975), 273 ff.

Reviews the law of California in an effort to clarify the legal issues involved in the controversy over public management of coastal resources and private property rights.

Brinkman, Waltraud A. R., Hurricane Hazard in the United States: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, Co.: 1975, 100 pp.

From the NSF/RANN funded assessment of research on natural hazards. Topics discussed are the physical aspects of hurricanes, population and property at risk, effects of and adjustments to the hurricane hazard, and research opportunities. A scenario of a hurricane landfall near Miami is included. 111 references.

Brouillete, John R., "The Department of Public Works: Adaptation to Disaster Demands." American Behavioral Scientist 13, (January-February, 1970), 369-379.

A discussion of the organization, function, and resources of the typical public works department, its role in emergency, its ability to cope with varying degrees of emergency, and what characteristics make it an effective organization for emergency response.

Brown, L. F., Jr., R. A. Morton, J. H. McGowen, C. W. Kreitler and W. L. Fisher, Natural Hazards of the Texas Coastal Zone. Bureau of Economic Geology, University of Texas at Austin in cooperation with the Texas Coastal and Marine Council: 1974, 13 pp., 7 maps.

The characteristics, major events, adjustments, and vulnerability to hurricanes, floods, coastal erosion, subsidence, and faulting are described in this atlas. Seven maps of the Texas Coastal Zone show the areas vulnerable to each of the hazards.

Bullard, Fred M., Volcanoes in History, in Theory, in Eruption. Austin: University of Texas Press, 1962, 441 pp.

Divided into three sections: Facts and Fiction about Volcanoes, Types of Volcanic Eruptions, and Theory, Cycles and Utilization of Volcanoes.

Burton, Ian, Types of Agricultural Occupance of Flood Plains in the United States. University of Chicago, Department of Geography, Research Paper No. 75, Chicago: 1962, 167 pp.

Hypotheses were developed for relationships between: 1) width of flood plain and land use, 2) width of flood plain and farm buildings, 3) slope of adjoining land and flood plain land use, 4) slope of adjoining land and farm buildings, 5) flood frequency and land use, 6) flood frequency and farm buildings, and 7) seasonality of flooding and flood plain land use. Groupings of these variables form descriptions of flood plain occupance. Five occupance types were found in twelve study areas chosen for heterogeneity of farming types and the variables considered, and some hypotheses were verified. Implications for public policy are discussed. Appendix: Theoretical Occupance Types.

Burton, Ian and Robert W. Kates, "The Flood Plain and the Seashore: A Comparative Analysis of Hazard-zone Occupance." Geographical Review 54, (1964), 366-385.

A comparison of coastal and riverine flood hazard in terms of hydrological features, geomorphic features, role of engineering works in hazard zone occupance, and advantages of the hazard areas for human occupance.

Burton, Ian and Robert W. Kates, "The Perception of Natural Hazards in Resource Management." Natural Resources Journal 3, (January, 1964), 412-441.

Discusses differences in perceptions of hazards within and between two groups: professionals who must deal with natural hazards on a scientific or technical basis, and resource managers. The variation in perception of hazards among professionals is discussed in terms of inadequate scientific knowledge and the indeterminate character of natural hazards. Differences between professional and manager perception is attributed to the acknowledgement of uncertainty by the professional, whereas four strategies for denying uncertainty are used by managers. Perceptions of managers are discussed in terms of: 1) scientific uncertainty, 2) relation of hazard to dominant resource use, 3) frequency of hazard, 4) attitudes toward nature, 5) reaction to uncertainty, 6) nature of the personal hazard, and 7) lack of concrete standard which can be applied to hazard-related decisions.

Burton, Ian, Robert Kates and Rodman Snead, The Human Ecology of Coastal Flood Hazard in Megalopolis. University of Chicago, Department of Geography, Research Paper No. 115, Chicago: 1969, 196 pp.

An analysis of coastal storm hazards in particular storm surge on the Atlantic coast. An overview of the coastal zone is followed by 15 case studies. The range and choice of human adjustments to coastal flooding, human use of the shore and implications of public policy are discussed.

Burton, Ian, Robert W. Kates and Gilbert F. White, The Human Ecology of Extreme Geophysical Events. Natural Hazards Research Working Paper No. 1, University of Toronto: 1968, 33 pp.

An overview of basic problems in natural hazards research relevant to the formulation and implementation of public policy. Topics discussed include hazard zone occupance, the range of human adjustment to natural hazards, hazard perception, the adoption of adjustments, optimal adjustment, the limits of adjustment, generalizability of response to hazards, and a note on the roles of uncertainty, crisis, and technology in the human response to natural hazards. 46 references.

Chow, Ven Te, Handbook of Applied Hydrology. New York: McGraw-Hill, 1964, approximately 1400 pp.

A comprehensive handbook dealing with sciences related to hydrology, hydrologic phenomena, practice and application of hydrology, and socio-economic aspects of hydrology. Numerous references follow each of 29 sections. Under the category of socio-economic aspects are sections on water resources planning and development, water law, water policy, and applications of electronic computers in hydrology.

Cochrane, Harold C., Natural Hazards and their Distributive Effects. Institute of Behavioral Science, University of Colorado, Boulder, Co.: 1975, 135 pp.

From the NSF/RANN funded assessment of research on natural hazards. Topics discussed are how natural events are characterized (scenarios and past events), effects of a disaster, burden of reconstruction, costs of reducing losses, and research opportunities. 169 references.

Connecticut, State of, Department of Environmental Protection, Coastal Areas of Particular Concern: Part I, Eleven State Approaches, Part II, An Approach for Connecticut. Hartford, Conn.: 1975, Multi. pp.
Provides a summary of eleven state administrative approaches to designating and managing Geographic Areas of Particular Concern as provided for in the CZM Act of 1972.

Council of State Governments, Comprehensive Emergency Preparedness Planning in State Government, by Hirst Sutton. Iron Works Pike, Lexington, Kentucky 40511: August 1976, 47 pp.
Discusses the integration of general state and state preparedness planning. Concerned with prevention, mitigation, long range recovery as well as immediate emergency response planning.

Cox, Poak C., "Introduction to Part II. Tsunamis." In: The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering. National Academy of Sciences, Washington, D.C.: 1972, 31-37.
Introduction to reports on tsunamis associated with the Alaska Earthquake of 1964. Reviews the various studies of tsunamis related to the earthquake.

__________, "Review of the Tsunami." In: The Great Alaska Earthquake of 1964: Oceanography and Coastal Engineering. National Academy of Sciences, Washington, D.C.: 1972, 354-360.
Summary of the major tsunami in the ocean and the large waves in the Prince William Sound and Gulf of Alaska associated with the Alaska earthquake of 1964.

Crandall, Tom, "Shoreline Development Controls and Public Access to the Ocean's Edge." Coastal Zone Management Journal, Vol. 1, No. 4 (1974), 451-466.
Describes the San Diego Coast Regional Commission's guidelines for bluff-top development. The guidelines include environmental and aesthetic parameters. Some of the factors leading to their formulation and adoption are discussed.

Crandell, Dwight R. and Howard H. Waldron, "Volcanic Hazards in the Cascade Range." In: Geologic Hazards and Public Problems: Conference Proceedings, edited by Robert A. Olson and Mildred M. Wallace. Office of Emergency Preparedness, Region Seven, Santa Rosa, California: 1969, 5-18.
Discusses lava flows, volcanic ash eruption, avalanches of ash and rock debris, floods, and mudflows and their potential danger from several dormant volcanoes in the Cascade Range. Concludes with suggestions for reducing volcanic hazard, some of which can be generalized to other regions.

Crumlish, Joseph D., "Some Economic Considerations in Evaluating Engineering Seismology Efforts." In: ESSA Symposium on Earthquake Prediction. U.S. Department of Commerce, Environmental Science Services Administration, Washington, D.C.: 1966, 119-122.
Compares earthquake damage in school buildings built before and after legislation requiring earthquake resistant construction for four California areas and for Seattle and Anchorage Schools.

Cypra, Kenneth and George L. Peterson, Technical Services for the Urban Floodplain Property Manager: Organization of the Design of the Problem. Natural Hazards Research Working Paper No. 12, University of Toronto: 1969.

Discusses technical advice services for flood plain managers based on the assumption that "services are simultaneously limited from above by the flood plain management effort and its supporting state of the art and below by the recipient's attitude towards such service."

Dacy, Douglas C. and Howard Kunreuther, The Economics of Natural Disasters: Implications for Federal Policy. New York: The Free Press, 1969, 270 pp.

The main objective of this book is to "formulate a clear-cut case for the development of a comprehensive system of disaster insurance as an alternative to the current paternalistic Federal policy." Conclusions and recommendations are supported with statistics and case studies. Chapter: 1, The Cost of Natural Disaster in the United States; 2, Relief in Natural Disasters; 3, Economic Theory and Natural Disaster Behavior; 4, Problems of Information and Communication; 5, Short-Run Supply and Demand Problems; 6, Planning for Recovery: The Special Problem of Damage Assessment; 7, Population Migration: The Supply of Labor; 8, Reconstruction and Economic Developments Following a Disaster; 9, The Small Business Administration Disaster Relief Program; 10, Equity in Disaster Relief; 11, The Cost of Federal Relief; 12, The Need for Comprehensive Disaster Insurance.

Day, J. H., H. P. Ho and V. T. Houghton, "Evaluation of Benefits of a Flood Warning System." Water Resources Research 5, (1969), 937-946.

Benefits from a flood warning system are estimated using individual structure damage curves for several warning periods. Data for residences, a grocery supermarket, and a railroad switchyard are used. The application of this technique to a 1959 flood indicates the extent of reducible damage. Evacuation and temporary flood proofing may also be evaluated by this method.

Day, John C., "A Recursive Programming Model for Nonstructural Flood Damage Control." Water Resources Research 6, (October, 1970), 1262-1272. See also An Activity Analysis of Nonstructural Floodplain Management Alternatives, University of Wisconsin Water Resources Center, Hydraulic and Sanitary Laboratory, Madison, Wisconsin 53706: 1969, 121 pp.

Presents a computational technique for evaluating land use alternatives based on the economic value a community gains from its land. A linear programming model is developed that identifies economically efficient combinations of: 1) spatial and temporal planning of urban land use, 2) site elevation through landfill, and 3) flood proofing of buildings.

Disaster Research Group, Field Studies of Disaster Behavior: An Inventory. Disaster Study No. 14, Washington, D.C.: National Academy of Sciences, National Research Council, 1961, 71 pp.

A catalogue of 114 field studies of 103 disaster situations which includes event, data, location, damage, number of interviews, research agency and principal research personnel, and reports and references.

Drabeck, Thomas E., "Social Processes in Disaster: Family Evacuation." *Social Problems* 16, (Winter 1969), 336-349.

Describes four types of evacuation patterns found in an interview study of responses to an evacuation warning prior to a major flood. The types of evacuation patterns were interrelated with source of warning and types of confirmation behavior.

Dulsik, Dennis W., *Shoreline For the Public: A Handbook of Social, Economic, and Legal Considerations Regarding Public Use of the Nation's Coastal Shoreline*. MIT Press, Cambridge, Massachusetts: 1974, 57 pp.

Emphasizes the legal aspects of the rights of public access to the nation's beaches. Includes less extensive treatment of social and economic considerations and a review of techniques for insuring public access.

Dynes, Russell R., "Organizational Involvement and Changes in Community Structure in Disaster." *American Behavioral Scientist* 13, (January-February, 1970), 430-439.

An analysis of the mobilization process in a disaster, centered around the idea that it is necessary for traditional organizational patterns to break down before mobilization can occur.

___________, *Organized Behavior in Disaster*. Lexington, Massachusetts: D. C. Heath, 1970.

A review and synthesis of previously published literature and supplemental material under the headings: Disaster-activated Organizations, The Disaster Event and Community Stress, Disasters and Community Organization, Disaster Activities and Organizational Functioning, Ways of Conceptualizing Organized Behavior, Problems of Organized Activity in Disaster, Interorganizational Relationships, and Changes in Community Structure in Disaster.

Erickson, Neil J., *Scenario Methodology in Natural Hazards Research*. Institute of Behavioral Science, University of Colorado, Boulder, Co.: 1975, 170 pp.

From the NSF/RANN funded assessment of research on natural hazards. Part I describes natural hazards as dynamic systems and evaluates the scenario model and method. The bulk of the monograph (Part II) is devoted to a scenario of the one per cent flood in Boulder, Colorado.

Federal Committee for Meteorological Services and Supporting Research, *A Federal Plan for Natural Disaster Warning and Preparedness*, Washington, D.C.: 1973.

A detailed description of systems for monitoring, warning and preparedness planning for all types of natural disasters.

Friedsam, H. J., "Older Persons in Disaster." In: *Man and Society in Disaster*, edited by George W. Baker and Dwight W. Chapman. New York: Basic Books, 1962, 151-182.

Discusses eleven hypotheses concerning the aged in disaster situations, with supporting research evidence. The hypotheses concern warning, evacuation, material loss, casualties, family ties, emotional response, and rehabilitation. The interview files of the Disaster Research Group were the primary source of data.

Fritz, Charles E., "Disasters Compared in Six American Communities." Human Organization 16, (Summer, 1957), 6-9.

Reports findings from a National Opinion Research Center disaster study centered around extensive interviews with those involved in six major disasters. Covers the social-psychological effects of disaster, common perceptions in disaster, initial behavior in disaster, leadership in disaster, and scapegoating in disasters.

Frutiger, Hans, "Behaviour of Avalanches in Areas Controlled by Supporting Structures." In: International Symposium on Scientific Aspects of Snow and Ice Avalanches, Reports and Discussions. Sponsored by the International Union of Geodesy and Geophysics and the International Association of Scientific Hydrology. L'Association Internationale d'Hydrologie Scientifique, Braamstraat 61, Gentbrugge, Belgium: 1966, 342-250.

Using summaries of several unpublished case studies of the failure of supporting structures, discusses the inadequacies of supporting structures in avalanche control.

Gaskin, Paul and J. Robert Stottlemyer, "Ecological and Economic Principles in Park Planning: The Assateague National Seashore Model." Coastal Zone Management Journal, Vol. 1, No. 4 (1974), 395 ff.

Proposes the incorporation of long term ecological and economic criteria into the decision-making process to avoid the adverse environmental impacts and high maintenance costs of inappropriate management schemes.

Georgia Department of Natural Resources, Handbook: Building in the Coastal Environment. Atlanta: 1975.

Discussion of legal, economic, and engineering aspects of developing property in the coastal zone. Explains functions of physical features and processes.

Goddard, James E., "Flood Plain Management Improves Man's Environment." Proceedings of the American Society of Civil Engineers, Waterways and Harbours Division 89, (WW4, November, 1963), 67-84.

Uses TVA flood control programs to illustrate how a comprehensive flood control program utilizing a variety of adjustments is desirable.

Haas, J. Eugene, "Lessons for Coping with Disaster." In: The Great Alaska Earthquake of 1964: Human Ecology. National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake, Washington, D.C.: 1970, 39-51.

Provides suggestions for community disaster planning gained from a field study of the Alaska earthquake, many of which apply to various kinds of disasters. Covers topics such as the warning system, supplemental and alternative communication, injury and damage assessment information, planning for search-and-rescue teams, providing for an Emergency Operations Center, and planning for the availability of resources, specialized information, and specialized equipment and skills.

Haas, J. Eugene and Patricia Trainer, "Effectiveness of Tsunami Warning System in Selected Coastal Towns in Alaska." Paper presented at the Fifth World Conference on Earthquake Engineering, Rome, Italy: 1973.

Develops a typology of tsunami events based on physical cues, available evacuation times and maximum credible preventive action. The effectiveness of the Alaska Regional Tsunami Warning System is evaluated. A short-term tsunami hazard education program produced no significant changes in knowledge of tsunamis, the warning system or in intended response. The personal contact and mass media approaches (but not direct mailings) did increase awareness of the threat.

Heck, Nicholas Hunter, Earthquakes. New York: Hafner, 1955, 222 pp.

An early, general work on the causes and study of earthquakes, including chapters on Descriptions of Great Earthquakes and Safe Construction in Earthquake Regions.

Hewitt, Kenneth and Ian Burton, The Hazardousness of a Place: A Regional Ecology of Damaging Events. University of Toronto Department of Geography Research Publication No. 6, Toronto: University of Toronto Press, 1971, 147 pp.

A categorization and statistical survey of past and potential hazards at London, Ontario. Topics such as frequency and intensity of various hazards and the range of damage and adjustments are included. Presents an interesting approach to a regional inventory of hazards.

Highway Research Board, Committee on Landslide Investigations, Landslides and Engineering Practice, edited by Edwin B. Eckel. HRB Special Report 29, NAS-NRC Publication No. 544, National Academy of Sciences, National Research Council, Washington, D.C.: 1958, 232 pp.

Contains ten chapters, including the following: Economic and Legal Aspects, by Rockwell Smith; Prevention of Landslides, by Arthur W. Root; and Control and Correction, by Robert F. Baker and Harry E. Marshall.

Hill, Reuben and Donald A. Hansen, "Families in Disaster." In: Man and Society in Disaster, edited by George W. Baker and Dwight W. Chapman. New York: Basic Books, 1962, 185-221.

Authors combine research findings on individuals and organizations in disaster and findings on families under stress to form five propositions about family interaction with the community in a disaster and six propositions concerning interaction within the family under disaster situations. An evaluation of the applicability of three conceptual frameworks for family-disaster research is presented.

Hodgson, John H., Earthquakes and Earth Structure. Englewood Cliffs: Prentice-Hall, 1964, 166 pp.

Contains chapters on: What are Earthquakes Like, How do Seismologists Study Earthquakes, Earthquakes Where and Why, and What Can We Do About Earthquakes.

Hollis, Edward P., Bibliography of Earthquake Engineering. Oakland, California: Earthquake Engineering Research Institute, 1971, (336 40th Street, Oakland, California 94609), 247 pp.

An annotated bibliography divided into the following sections: Miscellaneous Sources of Data; Seismic Geology, Seismology, and Seismometry; Dynamics of Soils, Rocks, and Structures; Design and Construction in Seismic Regions; and Earthquake Damage. Contains numerous subsections. Author index. Cross-indexed.

Homan, A. Gerlof and Bruce Waybur, A Study of Procedure in Estimating Flood Damage to Residential, Commercial and Industrial Properties in California. Stanford Research Institute, Menlo Park, California: 1960, 53 pp.

Discusses the results of a study of the effectiveness of water depth, value of content, and value of structure in estimating flood damage for residential, commercial, and industrial properties.

Hoyt, William G. and Walter B. Langbein, Floods. Princeton, New Jersey: Princeton University Press, 1955, 469 pp.

A classic on adjustments to floods. Chapters include: Why We Have Flood Problems; Life History of a Flood; Damage from Floods; Man's Adaptation to Floods; Protection through the Control of Water; Floods and the Constitution; Our Present Flood-Control Policy; Basin Problems, Projects, and Plans; and Flood History. Includes a catalogue of floods up to 1952.

Illinois, State of, Department of Transportation, Division of Water Resources, Geographical Areas of Particular Concern for the Illinois Coastal Zone Management Program (Draft). Chicago, Illinois: 1976, 13 pp.

Describes the efforts of the Illinois coastal zone management program in designating GAPC's. Includes a definition, process description and a list of GAPC nominations. Developed areas subject to storms, landslide, floods and coastal erosion are specifically mentioned as potential GAPC's.

__________, The Illinois Coastal Zone Management Program, First Year Work Product. Chicago, Illinois: 1975.

Volume I examines legal aspects, Volume II presents geological information (including: coastal erosion and lake level analyses; a physical characteristics inventory; hydrographic maps; and a sediment transport study) and Volume III discusses land use data and analysis.

James L. D., "Economic Analysis of Alternative Flood-Control Measures." Water Resources Research 3, (1967), 333-343. See also, James, L. D., A Time-Dependent Planning Process for Combining Structural Measures, Land Use, and Flood Proofing to Minimize the Economic Cost of Floods. Report EEP-12, Institute of Engineering-Economic Systems, Stanford University: 1964.

A computer program was developed for determining the optimum combination of structural and non-structural measures for flood control according to the criterion of economic efficiency. The program relates optimum combinations of channel improvement, flood proofing and land use control for each portion of the flood plain during planning stages of specified duration to specific flood plain properties. Total cost of the optimum program and a sensitivity analysis was related to variation in cost of channel improvement, cost of land use control, cost of flood proofing, right-of-way value, relationship between flood damage and flood severity, value of open space, extent of aversion to irregular timing of flood damage, discount rate, population projections, and the exclusion of alternative combinations.

________, "Nonstructural Measures for Flood Control." Water Resources Research 1, (1965), 9-24. See also, James L. D., A Time-Dependent Planning Process for Combining Structural Measures, Land Use, and Flood Proofing to Minimize the Economic Cost of Floods. Report EEP-12, Institute of Engineering-Economic Systems, Stanford University: 1964.

A procedure is presented for establishing a combination of structural measures, flood proofing, locational adjustment and damage absorbing to be applied in various proportions over time which satisfies the economic efficiency criterion. The technique was used to analyze a small watershed. Advantages of nonstructural measures and advantages of stage construction are discussed.

Janis, Irving L., "Psychological Effects of Warnings." In: Man and Society in Disaster, edited by George W. Baker and Dwight W. Chapman. New York: Basic Books, 1962, 55-92.

Hypotheses are presented concerning the following questions: 1) What warnings of potential danger result in effective preparation rather than denial or emotional overreaction and 2) under what conditions do prior warning, communications, or emotional adaptation produce sensitization to the disaster threat, and under what conditions do they produce underreactions? The hypotheses are supported with findings from disaster research. Conflicting, incomplete, or ambiguous evidence is noted.

Joint Committee on the San Fernando Earthquake Study, Earthquake Risk: Conference Proceedings. Sponsored by the Joint Committee on Seismic Safety of the California Legislature, 1971, 151 pp.

Includes articles on social benefits versus risk; decision-analysis on uncertain conditions; earthquake insurance; geologic hazards; risk and the decision-making process; costs and benefits of earthquake adjustments; liability resulting from earth movement; and others.

Kates, R. W., Hazard and Choice Perception in Flood Plain Management. University of Chicago Department of Geography Research Paper No. 78, Chicago: 1962, 157 pp.

Discusses the paradox that greater flood control leads to greater flood damages; also discusses resource problems and decision-making. Extensive interviewing of commercial managers and residents in LaFollette, Tennessee and reconnaissance studies of five other communities of differing geographical and socio-economic circumstances revealed several types of perception of flood hazard which differed from the scientific model. Greater variation of both perception and adjustments were found in areas of less perceived certainty of flood occurrence. The role of information in perception and adjustment is discussed. Appendix: Commercial Questionnaire.

Kates, Robert W., "Human Adjustment to Earthquake Hazard." In: The Great Alaska Earthquake of 1964: Human Ecology. National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake, Washington, D.C.: 1970, 7-31.

An analysis of the range of earthquake adjustments possible, actual adjustments practiced in Alaska before and after the earthquake and their adequacy, damage from the earthquake, the effect of the earthquake on earthquake adjustments, and implications for a national policy of reducing earthquake losses.

__________, "Natural Hazard in Human Ecological Perspective: Hypotheses and Models." Economic Geography 47, (July, 1971), 438-451. Also published as Natural Hazards Research Working Paper No. 14, Clark University, Worcester, Massachusetts, 1970.

Presents a series of linked hypotheses for natural hazard research concerning man-nature interaction, techno-social stages, nature of the hazard, decision-maker classes, and aspects of individual decision-making. Develops a model of human adjustment to natural hazards and a submodel of adjustment process control, then shows how the model can be applied to East African agricultural drought.

Kates, Robert W. and Gilbert F. White, "Flood Hazard Evaluation." In: Papers on Flood Problems, edited by Gilbert F. White, University of Chicago Department of Geography Research Paper No. 70, Chicago: 1961, 135-148.

Contains an analysis of the present state of the art of flood hazard evaluation and a guide for setting zoning regulation lines that are relatively easy to determine and understand. An example of the zoning guide applied to La Porte St., Plymouth, Indiana is included.

Kennedy, Will C., "Police Departments: Organization and Tasks in Disaster." American Behavioral Scientist 13, (January-February, 1970), 354-361.

A general discussion of the major functions of the police in a disaster and the problems associated with performing these tasks.

Kollmorgen, Walter M., "Settlement Control Beats Flood Control." Economic Geography 29, (1953), 208-215.

Reviews some Army Corps of Engineers flood control works in which the damages prevented were less than the cost of the program for a number of reasons. Discusses aspects of cost-benefit analysis of flood control which render the analysis inaccurate, such as failure to consider flood-caused soil improvement, disturbed hydrological conditions accompanying flood control works, mythical navigation benefits, etc. Suggests alternative adjustments to dams.

Kunreuther, H. K., et al., Limited Knowledge and Insurance Protection: Implications for Natural Hazard Policy. Unpublished draft: 1976.

The NSF/RANN funded project examined public response to flood and earthquake insurance offerings. Three principal conclusions are: 1) many people have little awareness of the hazard, 2) most of the uninsured could not estimate the cost of insurance, and 3) the public tends to view insurance as an investment, and expects a return, rather than as a means of sharing the cost of a natural disaster. See also, Kunreuther, "Limited Knowledge and Insurance Protection." Public Policy, Vols. 24 and 26 (Spring 1976).

Kunreuther, Howard and Elissandra S. Fiore, The Alaskan Earthquake: A Case Study in the Economics of Disaster. Institute for Defense Analysis, Economic and Political Studies Division: February, 1966, 162 pp.

A study of the immediate post-disaster recuperation, the long-term economic recovery, and the role of the federal government in the Alaskan Earthquake reconstruction. Some topics discussed are post-disaster organization, supply, and demand problems, external aids, labor migration patterns, public and private reconstruction, economic improvements, the Small Business Administration in Alaska, and the need for disaster insurance.

La Chapelle, Edward R., "The Character of Snow Avalanching Induced by The Alaska Earthquake." In: The Great Alaska Earthquake of 1964: Hydrology Part A. National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake, Washington, D.C.: 1968, 355-361.

Documents the extensive avalanching triggered by the Alaska Earthquake of 1964. Stable and unstable snow avalanched, mostly in normal paths although a few new ones were formed.

Lachman, Roy and William J. Bonk, "Behavior and Beliefs During the Recent Volcanic Eruption at Kapocho, Hawaii." Science 131, (1960), 1095-1096.

After a volcanic eruption in which attempts to divert lava flows by earthen dikes had failed, there were widespread offerings to the Hawaiian Volcano Goddess, a practice not limited to one religious creed, ethnic group, age level, or degree of educational achievement. This is attributed to the magnificence of the hazard and the failure of technology.

Lachman, Roy, Maurice Tatsuoka and William J. Bonk, "Human Behavior During the Tsunami of May 1960." Science 133, (May 5, 1961), 1405-1409.

After a tsunami for which warning was given, but not heeded by large numbers of people, interviews of both evacuees and non-evacuees were conducted. The principal finding was that the warning siren was incorrectly interpreted by the majority of non-evacuees. Socio-economic data on the two groups and prior disaster experience were also investigated as possible determinants of response.

Lantis, Margaret, "Impact of the Earthquake on Health and Mortality." In: The Great Alaska Earthquake of 1964: Human Ecology. National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake, Washington, D.C.: 1970, 77-89.

Discusses the types, causes and distribution of death, injury, and illness following the earthquake, the factors which kept the casualty rate unusually low, special medical problems in the disaster, medical record-keeping, and conclusions concerning medical planning for disasters.

Leighton, F. Beach, "Landslides." In: Geologic Hazards and Public Problems: Conference Proceedings, edited by Robert A. Olson and Mildred M. Wallace. Office of Emergency Preparedness, Region Seven, Santa Rosa, California: 1969, 97-132.

Describes the types and causes of mass land movement and describes adjustments that can be taken to prevent them or to avoid unstable sites.

Lomnitz, Cinna, "Casualties and Behavior of Populations During Earthquakes." Bulletin of the Seismological Society of America 60, (August, 1970), 1309-1313.

Studies of the relationship between time of day and casualties and the relationship between shocks and casualties in Chile lead to the inferences that it is safer, on the average, to be out-of-doors than indoors and that rapid evacuations of dwellings will reduce casualties.

Loughlin, James C., "A Flood Insurance Model for Sharing the Costs of Flood Protection." Water Resources Research 7, (1971), 236-244.

A cost sharing model complimentary to the 1968 flood insurance act for structural flood protection programs is proposed, related to savings in flood insurance premiums.

Macdonald, Gordon A., Volcanoes. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972, 510 pp.

A basic text on volcanoes including extensive discussion of volcanic structures, rocks, flows, eruptions, geothermal phenomena, distribution, internal mechanisms and the relationships between volcanoes and man (as benefactors and destroyers, predicting eruptions, and protective adjustments). An appendix catalogues the active volcanoes of the world.

Massachusetts, State of, Executive Office of Environmental Affairs, Erosion and Flooding Study: Critical Hazardous Areas. Boston, Massachusetts: 1976, 6 pp.

Describes a study analyzing natural hazards in the Massachusetts Coastal Zone.

Mather, John R., Richard T. Field and Gary Yoshioka, "Storm Damage Hazard Along the Eastern Coast of the United States." Journal of Applied Meteorology 6, (1967), 20-30.

Analyzes the frequency of damaging storms from 1935-1964, and discusses the causes of the increase in damaging storms. Includes a map of relative coastal storm damage hazard for three time periods.

Mathewson, C. C. and D. P. Piper, "Mapping the Physical Environment in Economic Terms." Geology, November, 1975, 627-629.

Presents a categorical quantitative procedure for classifying land with respect to development costs and risks.

Mears, Arthur I., "Guidelines and Methods for Detailed Snow Avalanche Hazard Investment in Colorado." Colorado Geological Survey Bulletin 38, 1976.

This summary of the avalanche hazard includes the character of avalanches, the effect of terrain, methods of determining the avalanche path, avalanche impact, frequency prediction, and avalanche defenses. May be useful in dealing with the hazard in other regions.

Michigan, State of, Water Development Services Division, Department of Natural Resources, Areas of Particular Concern in Michigan's Coastal Zone (Draft). Lansing, Michigan: 1975, 173 pp.
Identifies fifteen categories of areas of particular concern to the State of Michigan. Includes an overview, summary of criteria for selection, and problems and recommendations for each category.

Michigan, State of, Department of State Police, Emergency Services Division, Hazard Analysis, 2nd edition. Lansing, Michigan: May, 1974, 48 pp.
Reports and study of the types of natural disasters that have affected parts of the state as well as potential hazards related to future land uses.

Mileti, Dennis S., Natural Hazard Warning Systems in the U.S.: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, Colorado: 1975, 97 pp.
From the NSF/RANN funded assessment of research on natural hazards. Covers hazard characteristics relevant to warnings, types of warnings, a proposal for integration of the warning system, the prediction and forecasting of 15 natural hazards, community preparedness, societal factors and research opportunities.

Mississippi, State of, Marine Resources Council, Areas of Particular Concern and Priority of Uses. Long Beach, Mississippi: 1976, 24 pp. plus tables.
Considers potential and recommended areas of particular concern and presents an evaluation of priorities for use in a matrix form. Flooding, hurricanes and coastal erosion are specifically mentioned.

Mitchell, James K., Community Response to Coastal Erosion: Individual and Collective Adjustments to Hazard on the Atlantic Shore. University of Chicago, Department of Geography, Research Paper No. 156, Chicago: 1974, 209 pp.
A review of coastal erosion is followed by an examination of individual and collective adjustments to the hazard. Collective decision making processes were analyzed for five communities. No paradigm was found to explain the presence of conflict and the structure of the decision making. The citizen groups were generally composed of and led by people with endangered property.

Mukerjee, Tapan, Economic Analysis of Natural Hazards: A Preliminary Study of Adjustment to Earthquakes and Their Costs. Natural Hazards Research Working Paper No. 17, University of Toronto: 1971, 55 pp.
Contains a discussion of various adjustments to earthquakes; their costs and benefits; a benefit-cost analysis of warning systems; and structural modifications for the city of San Francisco. Includes: Bibliography on Earthquakes with Emphasis on Socio-economic Aspects.

National Academy of Sciences, Committee on Earthquake Engineering Research, Earthquake Engineering Research. Washington, D.C.: 1969, 313 pp.

For each of the following topics, describes the present state of knowledge, need for future research and recommendations: Socioeconomic Aspects of Earthquakes; Earthquake Ground Motion; Soil Mechanics and Earth Structure; Structural Dynamics Analysis; Structural Synthesis and Design; Coastal and Inland Waters; Utilities and Public Service Facilities; Post-Earthquake Inspection and Study; Foreign Cooperation; Education—Requirements for the Future. Bibliography

National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake, The Great Alaska Earthquake of 1964. 8 volumes, Washington: 1968-1973.

A collection of studies of the Alaska Earthquake of 1964 authorized by President Johnson and undertaken by the National Research Council. Volumes on hydrology, human ecology, biology, geology, seismology and geodesy, oceanography and coastal engineering, engineering, and summary and recommendations investigate the various physical and social phenomena related to the earthquake. See following two entries and individual articles referenced in this bibliography.

__________, The Great Alaska Earthquake of 1964: Human Ecology. Washington, D.C.: 1970, 510 pp.

Contains 14 articles under the general headings: Implications of the Earthquake Experience, Selected Studies of Impacts and Behavior, Public Administration Aspects, and the Human Response in Selected Communities. Appendices include: Chronologies of Events in Anchorage Following the Earthquake; Statistical Studies of the Post-disaster Period; Basic Population and Employment Statistics, South Central Alaska, 1960-1967; Federal Disaster Act; Alaska Omnibus Act; and Amendments to Alaska Omnibus Act. Annotated Bibliography.

__________, Toward Reduction of Losses from Earthquakes: Conclusions from the Great Alaska Earthquake of 1964. Washington, D.C.: 1969, 34 pp.

Presents and briefly discusses the Committee on the Alaska Earthquake's twelve recommendations on earthquake loss reduction measures, based on a review of the events before and after the Alaska Earthqauke of 1964. Also includes recommendations from the Committee's panels on geology, seismology, hydrology, biology, oceanography, engineering, and geography.

North Carolina, State of, Coastal Resources Commission, State Guidelines for Local Planning in the Coastal Area Under the Coastal Area Management Act of 1974. Raleigh, North Carolina: 1975, 71 pp.

Describes the North Carolina State guidelines to be used to assist local governments in each of the twenty coastal counties with preparation of their own land use plans. Includes a section on natural hazards.

Office of Management and Budget, Executive Office of the Budget, *1976 Catalog of Federal Domestic Assistance*. U.S. Government Printing Office, Washington, D.C. 20402: 1976, 806 pp. plus appendices.

Comprehensive listing and description of 1,026 Federal programs administered by 54 different agencies which provide assistance or benefits to the American public. Includes disaster relief programs.

Olson, Robert A. and Mildred M. Wallace, eds., *Geologic Hazards and Public Problems: Conference Proceedings*. Office of Emergency Preparedness, Region Seven, Santa Rosa, California: 1969, 335 pp.

Contains 20 articles on various aspects of several geologic hazards, concentrating on earthquake hazard and the Pacific Coast region, but also including landslide tsunami and volcanic hazards.

Oregon, State of, Land Conservation and Development Commission, *Draft-Oregon Coastal Management Program*. Portland, Oregon: February, 1976, 235 pp. plus maps.

Complete presentation of Oregon's Coastal Management Program. Guidelines include planning for geologic and flood hazards.

Perdikis, Harry S., "Hurricane-Flood Protection in the United States." *Proceedings of the American Society of Civil Engineers, Waterways and Harbours Division* 93, (WWI, February, 1967), 1-24.

Reviews the studies undertaken by the Army Corps of Engineers and the Weather Bureau on the engineering aspects and economics of structural measures for hurricanes along the Atlantic Seaboards. Includes tables of proposed protective works by area with maximum record flood and estimated damages, design stage, cost of construction, annual benefits, and benefit-cost ratio.

Pilkey, O. H., Jr., O. H. Pilkey, Sr. and R. Turner. *How to Live with an Island*. North Carolina Department of Natural and Economic Resources, Raleigh, North Carolina: 1975.

Written specifically as "A Handbook to Bogue Banks, N.C.," the book attempts to communicate technical knowledge of shoreline dynamics to the public. Discusses geological processes, ecological processes, conservation, site selection, construction guidelines, applicable laws, relevant publications.

Platt, Rutherford H., "The National Flood Insurance Program: Some Midstream Perspectives." *Journal of the American Institute of Planners*. (July, 1976), 303-314.

Evaluates flood plain management in the U.S., concluding that the National Flood Insurance Program is the most effective means yet proposed. Land use issues inhibiting full implementation of the program include questions of constitutionality of some measures, adequacy of flood plain information, allowing subsidized insurance for new construction in the emergency phase, and allowing "marginal encroachment" in the floodway fringe which may substantially alter the character of flooding and flood damages.

Pupura, J. A. and W. M. Sensabaugh, Coastal Construction Setback Line. SUSF-SG-74-002, Florida Cooperative Extension Service, Marine Advisory Program, Gainesville: 1974.

Describes Florida's setback law and procedures for its administration. Also describes factors employed in delineating the setback line.

Renshaw, Edward F., "The Relationship Between Flood Losses and Flood-Control Benefits." In: Papers on Flood Problems, edited by Gilbert F. White. University of Chicago Department of Geography Research Paper No. 70, Chicago: 1961, 21-45.

Adjustment to the flood hazard is discussed within the context of optimal economic development, development entailing social cost of secondary flooding, and factors contributing to general overinvestment in the flood plain. A discussion of why benefits of flood control are often over or under-estimated is followed by a "six point program for improving loss estimates."

Russell, C. S., Losses from Natural Hazards. Natural Hazards Research Working Paper No. 10, University of Toronto: 1969, 25 pp.

A general discussion of the role of various kinds of human adjustments and their interaction in the attempt to decrease losses from natural hazards.

Schaerer, P. A., "Planning Avalanche Defense for the Trans-Canada Highway at Rogers Pass, B.C." Engineering Journal 45, (March, 1962), 31-38. See also more detailed version, Schaerer, P. A., "Planning Avalanche Defense for the Trans-Canada Highway at Rogers Pass, B.C.," published by the Canadian National Research Council, Division of Building Research, Ottawa, November, 1962.

Describes the Avalanche survey taken to identify avalanche sites and assess the degree of hazard at each site; presents an avalanche classification; and discusses the possible adjustments to avalanches. The feasibility of using each kind of adjustment at Rogers Pass is discussed. The cost of various adjustments is compared, and an avalanche defense plan for the area is presented.

Selkregg, Lidia, Edwin B. Crittenden and Norman Williams, Jr., "Urban Planning in the Reconstruction." In: The Great Alaska Earthquake of 1964: Human Ecology. National Academy of Sciences, National Research Council, Committee on the Alaska Earthquake, Washington, D.C.: 1970, 186-239.

An analysis by community of the planning that took place after the earthquake, to what extent planning was implemented, and reasons for lack of or change in implementation. Concludes with suggestions for urban planning with regard to disasters and the proper role of federal and state government in that effort.

Sheehan, Leslie and Kenneth Hewitt, A Pilot Survey of Global Natural Disasters of the Past Twenty Years. Natural Hazards Research Working Paper No. 11, University of Toronto: 1969, 18 pp.

Includes world maps of a number of disastrous impacts, total loss of life from disasters excluding drought, and average number of deaths per disaster by 10° squares for 1947-1967. Tables: List of Unit

Disasters covering more than One 10° Square, Loss of Life and Number of Disaster Impacts by Nation-State, Loss of Life by Disaster Type and by Continents, Average Loss of Life Per Disaster Impact by Continents, and Percentage of Total Loss of Life for Each Disaster Type.

Sims, John H. and Duane D. Baumann, "The Tornado Threat: Coping Styles of the North and South." Science 176, (June 30, 1972), 1386-1392.

After briefly exploring and rejecting alternate explanations of the disproportionately high tornado death rate in the South, the authors present the results of a sentence completion test which indicate that southerners are more fatalistic, have less faith in the efficacy of their own actions and have less trust in society's warning system. It is concluded that psychological factors resulting in failure to take effective action cause higher tornado death rates in the South. Findings might be generalized to other hazards.

Sjorberg, Gideon, "Disasters and Social Change." In: Man and Society in Disaster, edited by George W. Baker and Dwight W. Chapman. New York: Basic Books, 1962, 356-384.

A general discussion of social change caused by disasters—war and epidemics as well as natural disasters—with regard to local versus widespread disasters, industrial versus pre-industrial societies, short-run versus long-run effects, and disasters in which there is hope of adjustment versus disasters in which hope is lacking.

Sorensen, John H. with J. Kenneth Mitchell, Coastal Erosion Hazard in the United States: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, Colorado: 1975, 63 pp.

From the NSF/RANN funded assessment of research on natural hazards. The dimension of the coastal erosion hazard in the U.S., the range of adjustments, social consequences, exogenous forces, current research, and research opportunities are discussed. 89 references.

Sorensen, J. H., W. J. Ericksen and D. S. Mileti, Landslide Hazard in the United States: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, Colorado: 1975, 73 pp.

From the NSF/RANN funded assessment of research on natural hazards. The dimension of the landslide hazard in the U.S. is discussed, as well as human adjustments to the hazard, its costs, exogenous forces, and research opportunities. 48 references.

Sugg, Arnold, "Economic Aspects of Hurricanes." Monthly Weather Review 95, (March, 1967), 143-146.

Total costs of protective measures against hurricanes in some areas are estimated and compared with damage reports from a few recent hurricanes. Costs, savings and damage figures vary with storm intensities and forecast accuracies.

Tennessee Valley Authority, Flood Damage Prevention: An Indexed Bibliography, 7th Edition. Knoxville, Tennessee: 1973.

Almost 500 references dealing with damage prevention, floodplain regulation and flood control. Listed chronologically and indexed by subject.

United Nations Educational, Scientific and Cultural Organization, Annual Summary of Information on Natural Disasters. No. 1, 1966; No. 2, 1967. Belgium: UNESCO, 1970, 66 and 81 pp.
Contains geological and meteorological information on earthquakes, tsunamis, storm surges, and volcanic eruptions, worldwide.

United States Army Corps of Engineers, Report on the National Shoreline Study. Washington, D.C. 30214: August, 1971, 62 pp.
The River and Harbor Act of 1968 (PL 90-483) authorized the Corps of Engineers to assess the extent and severity of coastal erosion in the United States, and to determine suitable methods for protecting the coast. This report is the project summary including data for the nine regions. The Regional Inventory Reports contain more detailed descriptions and data for each state. The two reports, Shore Management Guidelines and Shore Protection Guidelines, describe the various management and engineering techniques available as adjustments to coastal erosion. (See the following reference.)

___________, Shore Protection Guidelines. Washington, D.C.: 1971, 59 pp.
A general work, intended for the individual property owner considering various types of sand erosion or hurricane protection. A description of wave action and sand transport, man-made effects on the shore and the protective action of dunes, bulkheads, seawalls, revetments, breakwaters, groins, and jetties are discussed. Blueprints of structural measures and cost estimates of various adjustments are included.

___________, The Tsunami of the Alaskan Earthquake of 1964: Engineering Evaluation, by Basil W. Wilson and Alf Torum. Coastal Engineering Research Center, Technical Memorandum No. 25, 1968, 401 pp.
After an evaluation of the mechanism of tsunami generation based on field investigation and previous literature, detailed studies of the main tsunami and local seismic waves are given for damaged areas in Alaska, Canada, Washington, Oregon, and California, including engineering evaluations for severely damaged areas. Conclusions are presented for earthquake and tsunami generation characteristics, tsunami propagation characteristics, features of tsunami damage, and general design criteria for tsunami protection.

___________, Water Resources Development State Reports, 1975.
The Corps periodically produces a set of state reports on their civil engineering projects in each state. The introduction to these reports includes brief discussions of the purpose of the Corps, its legal foundation and the range of problems addressed by their activities. Brief summaries of flooding are included in several of the state reports.

United States Department of Agriculture, First Aid for Flooded Homes and Farms. Agricultural Handbook No. 38, Washington, D.C.: 1970, revised, 31 pp.
A fairly detailed report on how to clean up and repair flood damage to homes, household belongings, and farm equipment.

United States Department of Agriculture, Forest Service, Snow Avalanches: A Handbook of Forecasting and Control Measures. Agricultural Handbook No. 194, Washington, D.C.: revised, 1968, 84 pp.

Contains chapters on: Physics of the Snow Cover; Avalanche Characteristics; Terrain; Avalanche Hazard Forecasting; Standard Snow Observations and Terminology; Snow Stabilization; Safety; Avalanche Defenses; Avalanche Rescue; and Area Safety Planning.

United States Department of Commerce, Environmental Science Services Administration, Earthquakes. Washington, D.C.: 1969, 15 pp.

A pamphlet containing a simple explanation of the cause and measurement of earthquakes, a world earthquake belt map, a seismic risk map of the United States, and a list of earthquake safety rules.

___________, Hurricane. Washington, D.C.: 1969, 39 pp.

Contains an explanation of the cause, behavior, and death of hurricanes, the damage which can be caused by hurricanes, the ESSA hurricane warning service, what communities and individuals can do to protect against hurricanes, ESSA programs of research in hurricane control, and a short hurricane bibliography.

___________, A Plan for Improving the National River and Flood Forecast and Warning Service. Silver Springs, Maryland: December, 1969, 64 pp.

Outlines the present (1969) program and planned improvements which include, among other things, improved preparation and dissemination of flood forecasts and warnings, extending flash flood warnings to new locations, increased data acquisition, and providing advanced training for personnel. Includes charts on Loss of Life and Property in the United States from Floods, and Reduction of Flood Losses by Actions Based on River Forecasting.

___________, Some Devastating Hurricanes of the 20th Century. Washington, D.C.: 1970, 9 pp.

Contains maps and data on approximately fifty severe United States hurricanes from 1900-1969 including date, area, wind speed, deaths, and damage.

___________, Tsunami Watch and Warning. Washington, D.C.: 1968, 2 pp.

Explains the difference between a tsunami watch and warning, and lists tsunami safety rules.

United States Department of Commerce, Weather Bureau, The Climate of Texas and the Adjacent Coastal Waters, by Robert D. Orton. Washington, D.C.: U.S. Government Printing Office, 1964.

A review of the climate of Texas. Includes many tables of data, as well as brief summaries and explanations.

United States Department of Commerce, National Oceanic and Atmospheric Administration, The Homeport Story: An Imaginary City Gets Ready for a Hurricane. Washington, D.C.: 1971, 20 pp.

Presents a sample community hurricane preparedness plan.

United States Department of Commerce, National Oceanic and Atmospheric Administration, Operations of the National Weather Service. Silver Springs, Maryland: October, 1971, 231 pp.

Describes the organization and services of the National Weather Service, and its communication network. Particularly relevant are the descriptions of the warning services for various natural hazards. Includes maps of the service networks for each program.

United States Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, Earthquake History of the United States. Publication 41-1, revised edition (through 1970), Washington, D.C.: 1973, 208 pp.

Catalogue of earthquakes in the U.S. including dates, times, locations and intensities. More detailed descriptions of major earthquakes encompass their geographic distribution, effects and damages.

United States Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, Hurricane Experience Levels of Coastal County Populations—Texas to Maine, by Paul L. Hebert and Glenn Taylor. July, 1975.

This volume attempts to document the levels of experience of coastal populations. The introduction includes a description of the Saffir-Simpson Hurricane rating scale currently used by the NWS. Data on coastal county populations 1900-70 is correlated with the number of and frequency of hurricanes striking the country.

United States Geological Survey, The Alaska Earthquake of March 27, 1964, Lessons and Conclusions, by Edwin B. Eckel. USGS Professional Paper 546, Washington, D.C.: 1970, 57 pp.

A summary of the effects of the earthquake, what was learned from the extensive post-earthquake research program, and what scientific investigations are needed to prepare for future earthquakes. Bibliography. Related reports dealing with various aspects of the damage are: Effects on the Alaska Railroad (545-D), Effects on the Alaska Highway System (545-C), Effects on Air and Water Transport, Communications and Utilities (545-B), and Effects on Various Communities (542-G).

United States Geological Survey, Earth-Science Information in Land-Use Planning: Guidelines for Earth Scientists and Planners, by Spangle and Associates, et al. Geological Survey Circular 721, Arlington, Virginia: Branch of Distribution, 1976.

A nationwide sample of applications of earth-science information to urban land-use planning, prepared for the San Francisco Bay Region Environment and Resources Planning Study. A general but helpful study which covers sources, types and interpretation of information; planning for natural resources; planning for natural hazards; and integration of information in the planning process.

___________, "Preliminary Landslide Overview Map of the Coterminus United States," by Radbruch-Hall, D. H., R. B. Colton, W. E. Davis, B. A. Skipp, I. Lucchitta and D. J. Varnes. Department of the Interior, U.S. Geological Survey, 1976, 1 p.

Areas subject to landsliding are delineated on the basis of past incidence or susceptibility (as determined by the geological structure). A brief introduction describes the major areas of landsliding. Two other maps are included depicting the southern limit of Pleistocene glacial deposits and the physical subdivisions of the U.S. The landslide map contains references to more detailed articles of local landslide hazards.

__________, A Probabilistic Estimate of Maximum Acceleration in Rock in the Contiguous United States, by S. T. Algermissen and David M. Perkins. USGS, Open File Report 76-416, 1976.

Two maps are included in this report. Seismic source areas are delineated using estimates of the number of intensity V earthquakes per 100 years and the maximum intensity expected. The second map is more important. It depicts maximum amount of ground movement expected as a per cent of gravitational acceleration with a 10% probability of being exceeded in 50 years. This type of mapping delineates earthquake hazard areas and has potential for developing areas of special land use and building requirements.

United States Office of Emergency Preparedness, Report to the Congress Vol. 1: Disaster Preparedness. Washington, D.C.: 1972, 195 pp.

Contains chapters on disaster preparedness with regard to vulnerability, prediction and warning capability, preventive measures, and government response for general hazard, river floods, tornadoes and windstorms, hurricanes and storm surges, forest and grass fires, earthquakes, landslides, tsunamis, volcanoes, frosts and freezes, and droughts. Discusses land use and construction, disaster insurance, weather modification, and the application of science and technology. Presents historical data on legislation and statistical data.

__________, Report to the Congress Vol. 2: Disaster Preparedness. Washington, D.C.: USGPO, 1972, 25 pp.

An Example State Disaster Act of 1972 and commentary.

__________, Report to the Congress Vol. 3: Disaster Preparedness. Washington, D.C.: USGPO, 1972, 143 pp.

Consists of ten chapters covering causes and effects, threat and vulnerability, and technological countermeasures of the hazards river floods, tornadoes and grass fires, earthquakes, landslides, tsunamis, volcanoes, frosts and freezes, and droughts.

United States Office of Science and Technology, Report of the Task Force on Earthquake Hazard Reduction: Program Priorities. Washington, D.C.: 1970, 54 pp.

Presents and explains 28 major recommendations for earthquake hazard reduction, divided into three categories: benefits in less than five years, benefits between 5 and 10 years, and long-term benefits.

United States Water Resources Council, Regulation of Flood Hazard Areas to Reduce Flood Losses. Washington, D.C.: 1971, 578 pp.

Part 1, Conclusions, is based on the studies contained in Parts 2-6. A bibliography is included. Part 2 contains three draft statutes, with commentary, to enable a state agency to: a) regulate flood hazard areas in conjunction with local units, b) regulate flood hazard areas independent of local units, and c) to aid local units in regulating flood hazard areas. Part 3 discusses general and specific legal considerations. Part 4 discusses local riverine flood zoning ordinances and sets out alternative ordinances with commentary. Part 5 discusses and sets out a draft of subdivision regulations. Part 6 discusses management for coastal flood loss control and includes draft coastal zoning regulations.

University of Rhode Island, "Dangerous High Tides Can Now Be Predicted." NEMRIP Information 75, August, 1975, 2 pp.

Briefly reviews the work of NOAA scientist Fergus J. Wood regarding the prediction of coastal flooding caused when predictable high tides combine with strong onshore winds. For more details see: Wood, Fergus J., The Strategic Role of Perigean Spring Tides in Nautical History and North American Coastal Flooding. NOAA, U.S. Government Printing Office, Washington, D.C.: 1976.

Warheit, George, "Fire Departments: Operations During Major Community Emergencies." American Behavioral Scientist 13, (January-February, 1970), 362-368.

A general discussion of the functions and organization of fire departments, and the organizational problems that arise during disasters.

Warrick, Richard A., Volcano Hazard in the United States: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, Colorado: 1975, 144 pp.

From the NSF/RANN funded assessment of research on natural hazards. A summary of the nature of volcanoes, their location in the U.S., adjustments to the hazard, volcano risk assessment and research opportunities. 118 references.

Washington, State of, Department of Ecology, Shoreline Management Program Impact Measurement and Policy Projection: Project Status Report. Olympia, Washington: 1975, 97 pp.

Part I presents information on the development of a model to predict future patterns of shoreline uses as applied to Snohomish County, Washington. Part II presents a user's guide to the Snohomish County Shoreline Inventory System. At present coastal erosion is the only natural hazard included in the computer-based Inventory System.

The Water's Edge: The National Forum on the Future of the Floodplain, with Emphasis on Open Space and Outdoor Recreation, Supplemental Report. Sponsored by U.S. Department of the Interior, Bureau of Outdoor Recreation; the League of Women Voters of the United States; and National Association of Counties. Minneapolis: The National Forum, October, 1975, 52 pp.

Recommendations from five workshops—covering public and private policies, open space and outdoor recreation in urban/suburban communities, conservation of undeveloped flood plains, economic policies, and developing and implementing legislation—are designed to help Federal, state and local governments design more rational economic programs for flood plain use.

White, Gilbert F., *Changes in Urban Occupance of Flood Plains in the United States*. University of Chicago Department of Geography Research Paper No. 57, Chicago: 1958, 235pp.

A study of changes in urban occupance of flood plains between 1936 (when the Flood Control Act was enacted) and 1957, based on intensive studies of seventeen flood plain areas. In each case the flood plain and its present uses were mapped, changes in number and type of structure were estimated, and representative citizens and public officials were interviewed. The data revealed persistent human invasion of flood plains. The causes for the invasion are assessed, and implications for public policy are discussed.

__________, *Choice of Adjustment to Floods*. University of Chicago Department of Geography Research Paper No. 93. Chicago: 1964, 149pp.

An examination of conditions in which managers of flood plain property choose among eight possible adjustments, based upon intensive study of La Follette, Tennessee and reconnaissance study of five other towns differing widely in physical characteristics of flooding. Factors affecting the path which adjustment takes from the first use of flood plain land include perception of the possible adjustments, technical feasibility of particular adjustments, the economic efficiency of these choices, and the timing and incidence of decisions by the private and public managers. Implications for public policy are discussed. Includes two appendices: The Economic Effect of Local Flood Protection Measures by John Eric Edinger, and Form for Estimating Flood Losses and Adjustment Costs.

__________, *Flood Hazard in the United States: A Research Assessment*. Institute of Behavioral Science, University of Colorado, Boulder, Colorado: 1975, 141pp.

From the NSF/RANN funded assessment of research on natural hazards. The distribution, effects and adjustments to floods are discussed, as well as losses from floods, relevant national forces, scenarios (Rapid City and Boulder) and research recommendations. The appendix outlines a simulation model of flood losses for urban areas. 86 references.

__________, "Optimal Flood Damage Management: Retrospect and Prospect." In: *Water Research*, edited by Allen V. Kneese and Stephen C. Smith. Baltimore: Johns Hopkins, 1966, 251-269.

A review of what has been learned about flood damage management, what still needs to be learned, and what conclusions can be drawn from our present knowledge about warranted public action.

__________, ed., *Papers on Flood Problems*. University of Chicago Department of Geography Research Paper No. 70. Chicago: 1961, 221pp.

Includes thirteen original papers on or related to flood problems under the categories: Flood Losses and Flood Plain Occupance, Flood Characteristics, and Regulating Land Use.

__________, "Recent Developments in Flood Plain Research." *Geographical Review* 60, (1970), 440-443.

An overview of the most important recent developments in flood plain research.

White, G. F. and J. E. Haas, Assessment of Research on Natural Hazards. Cambridge, Massachusetts: MIT Press, 1975, 487pp.

This is the summary volume of the NSF/RANN funded assessment of research on natural hazards. Hazards discussed are hurricane, flood, severe storms, wind, frost and freezing, urban snow, earthquake and tsunami, landslide, snow avalanche, coastal erosion, drought and volcano. The distribution of the hazards; scenarios; levels of risk; range of adjustments; and research needs, strategies, and applications are covered in this volume. Other monographs in this series deal in more detail with specific topics.

White, G. F. et al. (Staff members of Assessment Project). Snow Avalanche Hazard in the United States: A Research Assessment. Institute of Behavioral Science, University of Colorado, Boulder, Colorado: 1975, 86pp.

From the NSF/RANN funded assessment of research on natural hazards. Describes the general character of avalanches, adjustments to the hazard, social consequences, exogenous influences and research opportunities. Also included is a brief scenario of a hypothetical Juneau, Alaska avalanche. 55 references.

Wiegel, Robert L., "Seismic Sea Waves." In: Geologic Hazards and Public Problems: Conference Proceedings, edited by Robert A. Olson and Mildred M. Wallace. Office of Emergency Preparedness, Region Seven, Santa Rosa, California: 1969, 53-75.

Describes types of damage that occur from tsunamis and discusses the relationship between earthquakes and tsunamis. Charts some relationships between earthquake characteristics and tsunamis, the average probability of a maximum wave height exceeding a given value in a given duration at Crescent City, California. Briefly discusses the wave dynamics of tsunamis and the phenomenon of locally generated tsunamis.

Wiggins, John H. Jr. and Donald F. Moran, Earthquake Safety in the City of Long Beach Based on the Concept of Balanced Risk. Palos Verdes Estates, California: J. H. Wiggins, Company, 1971, 43pp. See also shortened version in Perspectives on Benefit-Risk Decision Making, National Academy of Engineering, Washington, D.C.: 1972.

Develops a system for designing building codes for a specified level of earthquake risk. The system includes input on type of use and length of building life, as well as geological factors. In addition, a structural hazard grading scheme and structure repair scheme for existing buildings is presented. Earthquake codes developed by fourteen countries, an explanation of the balanced risk aspect of the code, inspection procedures, remedial repair and a plan for post-earthquake operations are also discussed. Appendices include: Factors Influencing Earthquake Intensity, Structural Factors which Modify Intensity, Earthquake Risk, Analysis Procedure, Factors Effecting Life Hazard, Summary of Fourteen Building Codes which Treat Earthquake, and A Model Ordinance for an Earthquake Building Code.

Wisconsin, State of, Department of Local Affairs and Development, Division of Emergency Government, Hazard Analysis, A Base for Disaster Readiness Activities, n.d.

Covers a wide range of hazards including natural hazards, land use hazards and environmental hazards. Numerous maps.

Wisconsin, State of, Department of Natural Resources, State Planning Office, Shore Erosion Study, Coastal Zone Management Development Program. December, 1975, 12pp.

Reviews the Wisconsin Shore Erosion Study, an effort to develop alternative methods of preventing and abating coastal erosion damage. Describes technical studies and current related studies.

SECTION VI

DIRECTORY OF SELECTED FEDERAL, STATE AND VOLUNTARY AGENCIES CONCERNED WITH NATURAL HAZARDS IN THE COASTAL ZONE

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Region 3: DE, DC, MD, PA, VA
Philadelphia Regional Office
625 Walnut St., Curtis Bldg.
Philadelphia, PA 19106
215-597-2560

Region 4: AL, FL, GA, MS, NC, SC
Atlanta Regional Office (Georgia)
Rm. 211, Pershing Point Plaza
1371 Peachtree St., N.E.
Atlanta, GA 30309
404-526-5585

Region 5: IL, IN, MI, MN, OH, WI
Chicago Regional Office
300 South Wacker Dr.
Chicago, IL 60606
312-353-5680

Region 6: LA, TX
Fort Worth Regional Office
Rm. 14C2, Earle Cabell Federal Bldg.
U.S. Courthouse, 1100 Commerce St.
Dallas, TX 75202
214-749-7401

Region 9: CA, HI
San Francisco Regional Office
450 Golden Gate Ave., P.O. Box 36003
San Francisco, CA 94102
415-556-4752

Region 10: AK, OR, WA
Seattle Regional Office
Arcade Plaza Bldg., 1321 Second Ave.
Seattle, WA 98101

FEDERAL DISASTER ASSISTANCE ADMINISTRATION
Regional Directors (RD) and Preparedness Officers (PO)

Region 1: CT, ME, MA, NH, RI
RD: E. Paul Hartzell
PO: Warren Pugh, Jr.
FDAA
150 Causeway Street, Rm 710
Boston, MA 02114
FTS 8-223-4271

Region 2: NY, NJ
RD: Thomas R. Casey
PO: Philip McIntire
FDAA
26 Federal Plaza
New York, NY 10007
FTS 8-264-8980

Region 3: DE, DC, MD, PA, VA
RD: Arthur T. Doyle
PO: Peter Cote
FDAA
Curtis Bldg. - 7th Floor
6th & Walnut St.
Philadelphia, PA 19106
FTS 8-597-9416

Region 4: AL, FL, GA, MS, NC, SC
RD: Thomas P. Credle
PO: Jim Hardee
FDAA
Suite 750
1375 Peachtree Street, N.E.
Atlanta, GA 30309
FTS 8-285-3641

Region 5: IL, IN, MI, MN, OH, WI
RD: Robert E. Connor
PO: James P. Butler
FDAA
300 South Wacker Drive, Rm. 520
Chicago, IL 60606
FTS 8-353-1500

Region 6: LA, TX
RD: Joe D. Winkle
PO: Jon Overmyer
FDAA
Federal Bldg., Rm. 13C28
1100 Commerce Street
Dallas, TX 75202
FTS 8-749-1411

Region 9: CA, HI
RD: Robert C. Stevens
PO: Terrence Meade
FDAA
120 Montgomery Street
San Francisco, CA 94104
FTS 8-556-8794

Region 10: AK, OR, WA
RD: William H. Mayer
PO: Richard A. Buck
FDAA
Arcade Bldg., Rm. M-16
1319 Second Avenue
Seattle, WA 98101
FTS 8-399-1310

FEDERAL INSURANCE ADMINISTRATION

Administrator
451 Seventh Street, SW
Washington, D.C. 20410
202-755-6770

Assistant Administrator for Flood Insurance
451 Seventh Street, SW
Washington, D.C. 20410
202-755-5581

Regional Flood Insurance Specialists

Region 1: CT, ME, MA, NH, RI
John F. Kennedy Federal Building
Room 405A
Boston, MA 02203
617-223-2616 or 2709

Region 2: NY, NJ
26 Federal Plaza
New York, NY 10007
212-264-4756 or 8021

Region 3: DE, DC, MD, PA, VA
Curtis Building
Sixth and Walnut Streets
Philadelphia, PA 19106
215-597-9581

Region 4: AL, FL, GA, MS, NC, SC
1371 Peachtree Stree, N.E.
Atlanta, GA 30309
404-526-2391

Region 5: IL, IN, MI, MN, OH, WI
300 South Wacker Drive
Chicago, IL 60606
312-353-0757

Region 6: LA, TX
New Federal Building
1100 Commerce Street
Dallas, TX 75202
214-749-7412

Region 9: CA, HI
450 Golden-Gate Avenue
P.O. Box 36003
San Francisco, CA 94102

Region 10: AK, OR, WA
Room 3068 Arcade Plaza Building
1321 Second Avenue
Seattle, WA 98101
206-442-1026

State Coordinating Agencies for Flood Insurance

ALABAMA
Alabama Development Office
Office of State Planning
State Office Building
501 Dexter Avenue
Montgomery, Alabama 36104

ALASKA
Department of Community and Regional Affairs
Division of Community Planning
Pouch B
Juneau, AK 99811

CALIFORNIA
Department of Water Resources
Post Office Box 388
Sacramento, CA 95802

CONNECTICUT
Department of Environmental Protection
Division of Water and Related Resources
Room 207, State Office Building
Hartford, CT 06115

DELAWARE
Division of Soil and Water Conservation
Department of Natural Resources and Environmental Control
Tatnall Building, Capitol
Dover, DE 19901

FLORDIA
Department of Community Affairs
2571 Executive Center Circle East
Howard Building
Tallahassee, FL 32301

GEORGIA
Department of Natural Resources
Office of Planning and Research
270 Washington Street, S.W., Rm. 707
Atlanta, GA 30334

HAWAII
Division of Water and Land Development
Department of Land and Natural Resources
P.O. Box 373
Honolulu, HI 96809

ILLINOIS
Governor's Task Force on Flood Control
300 North State St.
P.O. Box 475, Rm. 1010
Chicago, IL 60610

INDIANA
Division of Water
Department of Natural Resources
608 State Office Building
Indianapolis, IN 46204

LOUISIANA
State Department of Public Works
P.O. Box 44155
Capitol Station
Baton Rouge, LA 70804

MAINE
Office of Civil Emergency Preparedness
State House
Augusta, ME 04330

MARYLAND
Department of Natural Resources
Water Resources Division
State Office Building
Annapolis, MD 21401

MASSACHUSETTS
Division of Water Resources
Water Resources Commission
State Office Building
100 Cambridge Street
Boston, MA 02202

MICHIGAN
Water Resources Commission
Bureau of Water Management
Stevens T. Mason Building
Lansing, MI 48926

MINNESOTA
Division of Waters, Soils and Minerals
Department of Natural Resources
Centennial Office Building
St. Paul, MN 55101

MISSISSIPPI
Mississippi Research and Development Center
P.O. Drawer 2470
Jackson, MS 39205

NEW HAMPSHIRE
Office of Comprehensive Planning
Division of Community Planning
State House Annex
Concord, NH 03301

NEW JERSEY
Bureau of Water Control
Department of Environmental Protection
P.O. Box 1390
Trenton, NJ 08625

NEW YORK
Department of Environmental Conservation
Bureau of Water Management
Albany, NY 12201

NORTH CAROLINA
Division of Community Assistance
Department of Natural & Economic Resources
P.O. Box 27687
Raleigh, NC 27611

OHIO
Ohio Dept. of Natural Resources
Flood Insurance Coor. Building
Fountain Square
Columbus, OH 43224

OREGON
Executive Department
State of Oregon
Salem, OR 97310

PENNSYLVANIA
Department of Community Affairs
Commonwealth of Pennsylvania
Harrisburg, PA 17120

RHODE ISLAND
R.I. Statewide Planning Program
265 Melrose Street
Providence, RI 02907

SOUTH CAROLINA
South Carolina Water Resources Commission
P.O. Box 4515
Columbia, SC 29240

TEXAS
Texas Water Development Board
P.O. Box 13087
Capitol Station
Austin, TX 78711

VIRGINIA
Bureau of Water Control Management
State Water Control Board
P.O. Box 11143
Richmond, VA 23230

WASHINGTON
Department of Ecology
Olympia, WA 98501

WISCONSIN
Department of Natural Resources
P.O. Box 450
Madison, WI 53701

Servicing Company Offices

ALABAMA
The Hartford Insurance Group
Hartford Building
100 Edgewood Avenue
Atlanta, GA 30301
404-521-2059

ALASKA
Industrial Indemnity Co. of Alaska
P.O. Box 307
Anchorage, AK 99510
907-279-9441

CALIFORNIA-NORTHERN SECTION
Fireman's Fund American Insurance Companies
P.O. Box 3136
San Francisco, CA 94119
415-421-1676

CALIFORNIA-SOUTHERN SECTION
Fireman's Fund American Insurance Companies
P.O. Box 2323
Los Angeles, CA 90051
213-381-3141

CONNECTICUT
Aetna Insurance Company
P.O. Box 1779
Hartford, CT 06101
203-523-4861

DELAWARE
General Accident F & L Assurance Corp. Ltd.
414 Walnut Street
Philadelphia, PA 19106
215-238-5000

FLORIDA
The Travelers Indemnity Company
1516 East Colonial Drive
Orlando, FL 32803
305-896-2001

GEORGIA
The Hartford Insurance Group
Hartford Building
100 Edgewood Avenue
Atlanta, GA 30301
404-521-2059

HAWAII
First Insurance Co. of Hawaii, Ltd.
P.O. Box 2866
Honolulu, HI 96803
808-548-511

ILLINOIS
State Farm Fire & Casualty Co.
Illinois Regional Office
2309 E. Oakland Avenue
Bloomington, IL 61701
309-557-7211

INDIANA
United Farm Bureau Mutual Insurance Co.
130 East Washington Street
Indianapolis, IN 46204
317-263-7200

LOUISIANA
Aetna Technical Services, Inc.
P.O. Box 61003
New Orleans, LA 70160
504-821-1511

MAINE
Commercial Union Insurance Company
c/o Campbell, Payson & Noyes
27 Pearl St., Box 527 Pearl St. Station
Portland, ME 04116
207-774-1431

MARYLAND
U.S. Fidelity & Guaranty Company
P.O. Box 1138
Baltimore, MD 21203
301-539-0380

MASSACHUSETTS-EASTERN
Commerical Union Insurance Company
1 Beacon Street
Boston, MA 02108
617-725-6128

MICHIGAN
Insurance Company of North America
Room 300-Buhl Building
Griswold & Congress Streets
Detroit, MI 48226
313-963-4114

MINNESOTA-EASTERN SECTION
The St. PAUL Fire & Marine Insurance Company
P.O. Box 3470
St. Paul, MN 55165
612-222-7751

MISSISSIPPI
The Travelers Indemnity Company
5360 Interstate 55 North
P.O. Box 2361
Jackson, MS 39205
601-956-5600

NEW HAMPSHIRE
Commerical Union Insurance Company
1 Beacon Street
Boston, MA 02108
617-725-6128

NEW JERSEY
Great American Insurance Company
5 Dakota Drive
Lake Success, NY 11040
201-224-4200

NEW YORK
Great American Insurance Company
5 Dakota Drive
Lake Success, NY 11040
516-775-6900

NORTH CAROLINA
Kemper Insurance
1229 Greenwood Cliff
Charlotte, NC 28204
704-372-7150

OHIO-NORTHERN SECTION
Commercial Union Insurance Company
1300 East 9th St.
Cleveland, OH 44114
216-522-1060

OREGON
State Farm Fire & Casualty Company
4600 25th Avenue, N.E.
Salem, OR 97303
503-393-0101

PENNSYLVANIA
General Accident F & L Assurance Corp., Ltd.
414 Walnut Street
Philadelphia, PA 19106
215-238-5512

RHODE ISLAND
American Universal Insurance Co.
144 Wayland Avenue
Providence, RI 02904
401-351-4600

SOUTH CAROLINA
Maryland Casualty Company
P.O. Box 11615
Charlotte, NC 28209
704-525-8330

TEXAS
The Home Insurance Company
2100 Travis Street
Houston, TX 77002
713-225-0931

VIRGINIA
Insurance Company of North America
5225 Wisconsin Avenue, N.W.
Washington, D.C. 20015
202-244-2000

WASHINGTON
Fireman's Fund American Insurance Companies
1000 Plaza 600 Building
6th and Stewart
Seattle, WA 98101
206-587-3200

WISCONSIN
Aetna Insurance Company
5735 East River Road
Chicago, IL 60631
312-693-2500

US DEPARTMENT OF THE INTERIOR

Secretary
C Street Between 18th & 19th Streets, NW
Washington, D.C. 20240
202-343-1100

Field Committees, Chaired by the Regional Special Assistant to the Secretary

Northeast Region: CT, DE, MD, MA, ME, NH, NJ, NY, PA, RI, VA
John F. Kennedy Federal Building
Boston, MA 02203

Southeast Region: AL, FL, GA, MS, NC, SC
148 Cain Street, NE
Atlanta, GA 30303

North Central Region: IL, IN, MI, MN, OH, WI
230 S. Dearborn St.
Chicago, IL 60604

Southwest Region: LA, TX
517 Gold Ave., S.W.
Albuquerque, NM 87101

Pacific Northwest Region: OR, WA
Bonneville Building
P.O. Box 3621
Portland, OR 97208

Pacific Southwest Region: CA, HI
450 Golden Gate Avenue
P.O. Box 36098
San Francisco, CA 94102

Alaska Region: AK
P.O. Box 120
Anchorage, AK 99501

BUREAU OF LAND MANAGEMENT

Director
C Street Between 18th & 19th Streets, NW
Washington, D.C. 20240
202-343-1100

State Offices

ALASKA
555 Cordova St.
Anchorage, AK 99501
907-277-1561

CALIFORNIA
Federal Office Bldg., Rm. E-2841,
2800 Cottage Way
Sacramento, CA 95825
916-484-4676

Eastern States: AL, FL, LA, MI, MN, MS, WI
7981 Eastern Ave.
Silver Spring, MD 20910
301-427-7500

OREGON
729 N.E. Oregon St.
P.O. Box 2965
Portland, OR 97208
503-234-3361

BUREAU OF OUTDOOR RECREATION

Director
C Street Between 18th & 19th Streets, NW
Washington, D.C. 20240
202-343-1100

Regional Offices

Pacific Southwest: CA, HI
Box 36062
450 Golden Gate Ave.
San Francisco, CA 94102

Southeast: AL, FL, GA, MS, NC, SC
148 Cain Street
Atlanta, GA 30303
404-526-4405

Lake Central: IL, IN, MI, MN, OH, WI
3853 Research Park Drive
Ann Arbor, MI 48104
313-769-7481

Northeast: CT, DE, D.C., ME, MD, MA, NH, NJ, NY, PA, RI, VA
Federal Building
600 Arch Street
Philadelphia, PA 19102
215-597-7989

Northwest: AL, OR, WA
Federal Building, Rm. 990
915 2nd Ave.
Seattle, WA 98174
206-583-4706

South Central: LA, TX
5301 Central Ave., N.E.
Albuquerque, NM 87108
505-843-3502

BUREAU OF RECLAMATION

Commissioner
C Street Between 18th & 19th Streets, NW
Washington, D.C. 20240
202-343-1100

Regional Offices

MIDPACIFIC
Federal Office Building
2800 Cottage Way
Sacramento, CA 95825
916-484-4571

PACIFIC NORTHWEST
P.O. Box 043, 550 West Fort St.
Boise, ID 83724
208-342-2101

SOUTHWEST
Herring Plaza, Box H-4377
Amarillo, TX 79101
806-376-2401

GEOLOGICAL SURVEY

Director
National Center, USGS
12201 Sunrise Valley Drive
Reston, VA 22092
703-860-7411

Water Resources Division, Regional Offices

Western Region: AK, CA, HI, OR, WA
345 Middlefield Road
Menlo Park, CA 94024
415-323-8111

Central Region: LA, TX
Denver Federal Center
Denver, CO 80225
303-234-3661

Northeastern Region: CT, IL, IN, ME, MD, MA, MI, MN, NH, NJ, NY, OH, PA, VA, WI
Room 317 Washington Building
Arlington Towers
Arlington, VA 22209
202-343-8441

Southeastern Region: AL, FL, GA, MS, NC, SC
1459 Peachtree St., N.E.
Suite 200
Atlanta, GA 30309
404-526-5395

District Offices

ALABAMA
P.O. Box V
University, AL 35486

ALASKA
218 "E" Street
Skyline Building
Anchorage, AK 99501

CALIFORNIA
855 Oak Grove Avenue
Menlo Park, CA 94025

CONNECTICUT
P.O. Box 715
Room 235 PostOffice Building
135 High Street
Hartford, CT 06101

DELAWARE
8809 Satyr Hill Road
Parkville, MD 21234

DISTRICT OF COLUMBIA
8809 Satyr Hill Road
Parkville, MD 21234

FLORIDA
Suite F-240
325 John Knox Road
Tallahassee, FL 32303

GEORGIA
6481 Peachtree Industrial Boulevard
Suite B
Doraville, GA 30340

HAWAII
5th Floor, 1833 Kalakaua Avenue
Honolulu, HI 96815

ILLINOIS
P.O. Box 1026
605 N. Neil Street
Champaign, IL 61820

INDIANA
1819 N. Meridian Street
Indianapolis, IN 46202

LOUISIANA
6554 Florida Boulevard
P.O. Box 66492
Baton Rouge, LA 70806

MAINE
State House Annex - Subdistrict
Capitol Shopping Center
Augusta, ME 04330

MARYLAND
8809 Satyr Hill Road
Parkville, MD 21234

MASSACHUSETTS
150 Causeway Street, Suite 1001
Boston, MA 02114

MICHIGAN
2400 Science Parkway
Red Cedar Research Park
Okemos, MI 48864

MINNESOTA
Room 1033 Post Office Building
St. Paul, MN 55101

MISSISSIPPI
430 Bounds Street
Jackson, MS 39206

NEW HAMPSHIRE
150 Causeway Street, Suite 1001
Boston, MA 02114

NEW JERSEY
P.O. Box 1236
Room 420, Federal Building
402 East State Street
Trenton, NJ 08607

NEW YORK
P.O. Box 1350
343 U.S. Post Office & Court House
Albany, NY 12201

NORTH CAROLINA
P.O. Box 2857
Room 440, Century Station, P.O. Building
Raleigh, NC 27602

OHIO
975 W Third Avenue
Columbus, OH 43212

OREGON
P.O. Box 3202
830 N.E. Hollsdey Street
Portland, OR 97208

PENNSYLVANIA
P.O. Box 1107
4th Floor Federal Building
288 Walnut Street
Harrisburg, PA 17108

RHODE ISLAND
150 Causeway Street, Suite 1001
Boston, MA 02114

SOUTH CAROLINA
2001 Assembly Street, Suite 200
Columbia, SC 29201

TEXAS
630 Federal Building
300 E. 8th Street
Austin, TX 78701

VIRGINIA
200 W. Grace Street, Room 304
Richmond, VA 23220

WASHINGTON
Room 300, 1305 Tacoma Avenue South
Tacoma, WA 98402

WISCONSIN
Room 228
1815 University Avenue
Madison, WI 53706

NATIONAL PARK SERVICE
Regional Offices

MIDATLANTIC REGION
143 South Third Street
Philadelphia, PA 19106
215-597-7013

MIDWEST REGION
1709 Jackson St.
Omaha, NE 68102
402-221-3431

NORTH ATLANTIC REGION
150 Causeway St.
Boston, MA 02114
617-223-3768

PACIFIC NORTHWEST REGION
523 Fourth and Pike Building
Seattle, WA 98101
206-442-5565

SOUTHEAST REGION
1895 Pheonix Blvd.
Atlanta, GA 30349
494-289-9242

SOUTHWEST REGION
P.O. Box 728
Santa Fe, NM 87501
505-988-6388

WESTERN REGION
450 Golden Gate Avenue
Box 36036
San Francisco, CA 94102
415-556-4196

OFFICE OF WATER RESEARCH AND TECHNOLOGY

Director
C Street Between 18th & 19th Streets, NW
Washington, D.C. 20240
202-343-2191

US DEPARTMENT OF LABOR

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

Assistant Secretary
3rd Street & Constitution Ave., N.W.
Washington, D.C. 20210
202-393-2420

Regional Offices

Region 1: CT, ME, MA, NH, RI
Vernon A. Strahn
Assistant Regional Director
18 Oliver St.
Boston, MA 02110

Region 2: NY, NJ
Alfred Barden
Assistant Regional Director
1515 Broadway,
New York, NY 10036

Region 3: DE, DC, MD, PA, VA
David H. Rhone
3535 Market Street
Philadelphia, PA 19104

Region 4: AL, FL, GA, MS, NC, SC
Donald E. MacKenzie
Assistant Regional Director
1375 Peachtree St, NE
Atlanta, GA 30309

Region 5: IL, IN, MI, MN, OH, WI
Edward E. Estkowski
Assistant Regional Director
230 S. Dearborn St.
Chicago, IL 60606

Region 6: LA, TX
Robert Tice
Assistant Regional Director
1512 Commerce St.
Dallas, TX 75201

Region 9: CA, HI
Gabriel J. Gillotti
Assistant Regional Director
Federal Building, P.O. Box 36017
San Francisco, CA 94102

Region 10: AK, OR, WA
James W. Lake
Assistant Regional Director
506 2nd Ave.
Seattle, WA 98104

OTHER FEDERAL AGENCIES

ENVIRONMENTAL PROTECTION AGENCY

Administrator
401 M Street, SW
Washington, D.C. 20460
202-755-2673

Regional Administrators

Region 1: CT, MA, MN, NH, RI
John A. S. McGlennon
John F. Kennedy Federal Bldg., Rm 2203
Government Center
Boston, MA 02203
617-223-7210

Region 2: NY, NJ
Gerald Hansler
26 Federal Plaza, Rm. 1009
New York, NY 10007
212-264-2525

Region 3: DE, DC, MD, PA, VA
Daniel J. Snyder
Curtis Building
6th and Walnut Sts.
Philadelphia, PA 19106
215-597-9814

Region 4: AL, FL, GA, MS, NC, SC
Jack E. Ravan
1421 Peachtree St., NE, Suite 300
Atlanta, GA 30309
404-526-5727

Region 5: IL, IN, MI, MN, OH, WI
Francis T. Mayo
230 S. Dearborne, 12th Fl.
Chicago, IL 60604
312-353-5250

Region 6: LA, TX
George J. Putnicki
1600 Patterson St.
Dallas, TX 75201
214-749-1962

Region 9: CA, HI
Paul DeFalco, Jr.
100 California St.
San Francisco, CA 94111
415-556-2320

Region 10: AK, OR, WA
Clifford V. Smith, Jr.
1200 6th Avenue
Seattle, WA 98101
206-442-1200

FEDERAL REGIONAL COUNCILS

Region 1: CT, ME, MA, NH, RI
Federal Regional Council of New England
E-431 John F. Kennedy Federal Bldg.
Boston, MA 02203
617-223-5421

Region 2: NJ, NY
Region 2 Federal Regional Council
Federal Plaza, Rm. 3543-A
New York, NY 10007
212-264-0723

Region 3: DE, DC, MD, PA, VA
Mid-Atlantic Federal Regional Council
4450 Federal Building, 600 Arch St.
Philadelphia, PA 19108
215-597-3653

Region 4: AL, FL, GA, MS, NC, SC
Southeastern Federal Regional Council
Peachtree St., NE, Rm. 515
Atlanta, GA 30309
404-526-2287

Region 5: IL, IN, MI, MN, OH, WI
Region 5 Federal Regional Council
300 South Wacker Drive-18th Flr.
Chicago, IL 60606
312-353-8184

Region 6: LA, TX
Southwest Federal Regional Council
1100 Commerce St., Rm. 9C-28
Dallas, TX 75202
214-749-1431

Region 9: CA, HI
Western Federal Regional Council
450 Golden Gate Ave., P.O. Box 36098
San Francisco, CA 94102
415-556-1970

Region 10: AK, OR, WA
Northwest Federal Regional Council
1321 Second Ave., M.S. 130
Seattle, WA 98101

GENERAL SERVICES ADMINISTRATION

Administrator
General Services Building
18th and F Streets, NW
Washington, D.C. 20405
202-343-1100

Director, Office of Preparedness
General Services Building
18th and F Streets, NW
Washington, D.C. 20405
202-343-1100

Regional Administrators

Region 1: CT, ME, MA, NH, RI
Albert A. Cammal, Jr.
John W. McCormack Post Office and Courthouse
Boston, MA 02109
617-223-2601

Region 2: NJ, NY
Gerald J. Turetsky
26 Federal Plaza
New York, NY 10007
212-264-2600

Region 3: DE, DC, MD, PA, VA
John F. Galuardi
Seventh and D Sts., S.W.
Washington, D.C. 20407
202-472-1100

Region 4: AL, FL, GA, MS, NC, SC
Lewis D. Strom
1776 Peachtree St., N.W.
Atlanta, GA 30309
404-285-5600

Region 5: IL, IN, MI, MN, OH, WI
Frank Resnik
219 S. Dearborn St.
Chicago, IL 60604
312-353-5395

Region 7: LA, TX
Jay H. Bolton
819 Taylor Street
Fort Worth, TX 76102
817-334-2321

Region 9: CA, HI
Thomas E. Hannon
49 4th St.
San Francisco, CA 94105
415-556-3221

Region 10: AK, OR, WA
David L. Head
Regional Headquarters Bldg.
GSA Center
Auburn, WA 98002
206-396-5201

OFFICE OF EMERGENCY PREPAREDNESS

Director
Executive Office of the President
Washington, D.C. 20504

WATER RESOURCES COUNCIL

Director
2120 L Street, NW
Washington, D.C. 20037
202-254-6303

River Basin Commissions

James F. Wright, Executive Director
Delaware River Basin Commission
25 State Police Drive
Box 360
Trenton, NJ 08603
609-883-9500

Frederick O. Rouse, Chairman
Great Lakes Basin Commission
P.O. Box 999
Ann Arbor, MI 48106
313-374-5431

R. Frank Gregg, Chairman
New England River Basins Commission
Room 205
55 Court Street
Boston, MA 02108
617-223-6244

Donel J. Lane, Chairman
Pacific Northwest River Basins Commission
P.O. Box 908
1 Columbia River
Vancouver, WA 98660
206-694-2581

Robert J. Bielo, Executive Director
Susquehanna River Basin Commission
Interior Building
Washington, D.C. 20240
202-343-4091

Designated State Agencies

ALABAMA
R. C. Bamberg, Director
Alabama Development Office
State Office Building
Montgomery, AL 36104
205-269-7171

ALASKA
Charles F. Herbert, Com.
Dept. of Environmental Conservation
Pouch M
Juneau, AK 99801
206-442-0150, ask for 586-6352

CALIFORNIA
William R. Gianelli
Director
Department of Water Resources
P.O. Box 388
Sacramento, CA 95802
916-445-5656

CONNECTICUT
Dan W. Lufkin, Commissioner
Department of Environmental Protection
Room 539, State Office Building
165 Capitol Avenue
Hartford, CT 06115
203-566-4255

DELAWARE
Austin N. Heller, Secretary
Dept. of Nat. Res. & Environmental Control
Natural Resources Building
Dover, DE 19901
302-678-4000

DISTRICT OF COLUMBIA
James Alexander, Director
Water Resources Management Admin.
Dept. of Environmental Services
415-12th Street, NW
Washington, D.C. 20004
202-629-3415

FLORIDA
Randolph Hodges, Exec. Dir.
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APPENDICES

APPENDICES

A. "The Hurricane Problem" - A Statement of Concern by the American Meteorological Society as adopted by the Executive Committee on July 2, 1976.

B. "Legal Aspects of Natural Hazards Regulation in the Coastal Zone," Rutherford H. Platt.

C. "Modified Mercalli Intensity Scale of 1931" (Abridged) from Harry O. Wood and Frank Neumann, in Bulletin of the Seismological Society of America, Vol. 21, No. 4, December, 1931.

D. "Scenario of Hurricane Disaster in Miami, Florida," from Gilbert F. White and J. Eugene Haas, Assessment of Research on Natural Hazards, 1975.

E. "Barrier Islands - Hurricane Adjustments" and "Mainland Coasts - Earthquake Adjustments," Sample outlines of possible adjustments to regional natural hazard problems.

F. "A Check-List of Possibly Relevant State Programs."

A. "The Hurricane Problem" -A Statement of Concern by the American Meteorological Society as adopted by the Executive Committee on July 2, 1976.

Is the United States building toward a hurricane catastrophe?

Many members of the American Meteorological Society have voiced such a concern. Recent reports by the Institute of Behavioral Science of the University of Colorado, supported by the National Science Foundation, have highlighted the problem.

People seeking new life styles have moved to the hurricane-vulnerable areas. The population in the states bordering the Atlantic and Gulf of Mexico has increased out of proportion to the rest of the United States. Since 1960, beach front subdivisions have shown a 45% rise compared to 13% for the nation as a whole. There are now about 37 million people living in coastal counties from Texas to Maine.

The hurricane's storm surge is the biggest killer. Ninety percent of those who lose their lives in a hurricane are killed by the storm surge. Wind and inland fresh-water flooding claim the remainder. Thousands are injured. More than 6 million people are currently exposed to the storm surge hazard.

Summer tourists add another dimension. For example, Cap May County, N.J., has a permanent population of 60,000, but during a summer weekend a million visitors may invade this community. On the Outer Banks of North Carolina, 10 times as many visitors as residents flock there during the summer. On a given weekend, the number of people on the Banks can go as high as 150,000.

The Atlantic coastal states are particularly vulnerable. The greatest increases in population are taking place in areas that have been been free from significant hurricane activity for many years. During the last 15 years, the major* hurricanes have occurred in the states along the Gulf of Mexico. It has been 15 years since residents of the eastern seaboard have witnessed a major hurricane. This pattern could be reversed at any time and all coastal areas are potentially vulnerable.

The situation in Florida is even more critical. Except for Eloise in 1975, only two major hurricanes struck Florida during the

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*A major hurricane is defined as a category 3, 4, or 5 storm on a scale of 1-5. Storm surges range from 9 to greater than 18 feet. Winds would range from 111 to more than 155 miles per hour in a type 5 storm. Hurricane Camille in 1969 and the Labor Day storm in the Keys in 1935 were the only "5" hurricanes this century in the United States.

past 25 years--Betsy, 1965, and Donna, 1960--and the damage from both of these was confined mainly to the Keys. In 1950, the population of coastal counties in Florida was 2 million. Today, 5.5 million people live on the coast. Extremely serious questions are therefore raised.

What is the level of experience along our coast? Are coastal counties and communities prepared to cope with the myriad problems posed by a major hurricane's landfall?

Will individuals and families respond properly to hurricane warnings and advice? How does hurricane experience affect their warning response?

In 1957, Hurricane Audrey claimed almost 400 lives when it struck Cameron Parish, La. Many residents chose not to heed the warnings and evacuate. Four years later, 97% of Cameron Parish residents fled from Hurricane Carla.

Many people who go through the fringes of a major hurricane or through a weak hurricane are lulled into a false sense of security. That's what happened in Cameron Parish in 1957.

Eighty percent of the coastal residents of Florida, one of the most hurricane-prone states in the nation, are inexperienced. There are a million people in the Tampa Bay area, and over 50,000 live on offshore islands where the average elevation is from 4 to 6 feet above sea level. The last major hurricane over Tampa Bay occurred in 1921 when the population was about 100,000. Ninety percent of the Tampa Bay residents are inexperienced.

The Georgia coast has not been struck by a major hurricane this century. Many Georgians feel immune from hurricanes. A survey by a Savannah newspaper showed that most of the people on Savannah Beach do not plan to evacuate if threatened by a major hurricane. The same is true at beautiful Hilton Head Island, S.C. Yet in 1893, a storm surge of 15-20 feet inundated many of the islands along the Georgia and South Carolina coasts and killed over 2,000 people.

Even in the Gulf of Mexico, where the frequency of hurricanes should have taught builders and planners to consider hurricane safety measures, one finds emphasis on the hurricane problem lacking. Along the Texas coast, for example, the population on the south end of Padre Island is ready to explode. A community of 50,000 is planned on the north end of Padre Island across the Bay from Corpus Cristi. Key Allegro is a large dredge-and-fill operation at Rockport less than 80 miles south of Port Lavaca, where Carla in 1961 pushed water levels to 20 feet above normal. The western end of Galveston Island is being developed beyond the sea wall.

Of the 37 million people now living in coastal counties, 78% have never experienced the destructive core of a major hurricane.

Our nation's warning system has shown steady improvement in its ability to forecast and warn of a hurricane's approach to land. As a result, the average annual loss of life has decreased significantly. However, the improved technology and skills are not keeping pace with the problems created by the continually increasing coastal population. For example, how many people can be evacuated ahead of a fast-moving storm like Hazel in 1954. Or the 1938 storm that killed 600 as it went through New York, Connecticut, Rhode Island, and Massachusetts at a forward speed of 56 miles an hour?

Experts are worried that the existing trend of decreasing fatalities may not continue. They fear a future hurricane disaster that will equal or surpass the Galveston tragedy of 1900 when 6,000 people died.

A recent research assessment* gives four prominent interrelated reasons that support this fear:

1) increased urbanization with its concomitant heightened risk of catastrophe;
2) inadequacy of evacuation routes;
3) insufficient refuge;
4) unenforcement of building safety codes.

This statement is not an indictment of coastal living. The beach offers a beautiful way of life. The statement is a plea for realistic hurricane preparedness plans at state, county, and local levels. Efforts to promote proper hurricane awareness and response to the hurricane threat must be accelerated.

Community leaders must plan for ways of evacuating people. It is no longer practical to depend entirely on evacuation by automobile to get people to higher ground. Contingency plans should consider evacuation into well-constructed high-rise buildings when horizontal evacuation becomes impossible. Many areas with limited access roads must adopt plans to get people out when the hurricane threat is first realized. If we do not initiate ways of informing our coastal communities of the hurricane problem, Mother Nature will impose her own education program, which is swift and severe.

*"Hurricane Hazard in the United States" by Waltraud A. R. Brinkmann, University of Wisconsin.

B. "Legal Aspects of Natural Hazards Regulation in the Coastal Zone," Rutherford H. Platt.

The objectives of private owners of coastal property and public coastal zone managers are usually incompatible. As noted by Herman Melville at the beginning of Moby Dick:

> What do you see? -- Posted like silent sentinels all around the town, stand thousands upon thousands of mortal men fixed in ocean reveries . . . . But look! here come more crowds, pacing straight for the water and seemingly bound for a dive. Strange! Nothing will content them but the extremist limit of land , . . . they must get just as nigh the water as they possibly can without falling in.

A corollary to Melville's observation is that this attraction may prove fatal if the beholder approaches the water's edge too closely and for too long.

The American legal system affords three basic tools for the public management of land use in coastal zones and elsewhere. The first is the power to acquire land and water rights either through voluntary sale or gift or through exercise of the public power of eminent domain. Secondly, private land may be regulated by public authority in the interest of protecting the "public health, safety and welfare" without payment of compensation. Thirdly, the public may seek to influence responsible private land and water management by providing tax incentives or other inducements. Public planning and management of coastal zones under PL 92-583 and its state counterparts must of necessity be based upon some combination of these three fundamental legal strategies. The foremost dilemma of coastal zone planning is which tool to use where and by which level of government.

Public acquisition is of course the most reliable and judicially safe means by which to exert public control over any land area. Where a genuine public use or purpose such as recreation, economic development, or flood damage protection is contemplated, coastal areas may be readily acquired through eminent domain upon payment of "just compensation" to the private owner. In the case of recreational sites, the Federal government may provide fifty percent (50%) of the acquisition cost to state and local governments under the Land and Water Conservation Fund (PL 88-578).

Outright acquisition even with Federal assistance however is enormously expensive in the coastal zone. Undeveloped coastal land accessible to metropolitan areas may easily cost as much as $100,000 per acre. Furthermore, additional costs are incurred in preparing and managing the site for public use. Understandably, the power to acquire land is used very selectively in the coastal zone, as elsewhere.

This leaves the regulatory and incentive approaches for the management of the remainder of the nation's shorelines. Unfortunately, the use of incentives to encourage wise use of shorelines is not widespread at this time. The granting of a zoning bonus, as is used to procure downtown plazas and parks, has not been utilized in the coastal context. Similarly, the concept of "transfer of development rights" which has been proposed for the preservation of historic landmarks and farmlands, has had little experience anywhere, let alone in the coastal zone.

Gifts of land to public or charitable entities are eligible for a federal income tax deduction. A gift of the right to develop land ("conservation easement") qualifies for a tax deduction as well as a reduction of property taxes on the retained interests. But such tax incentives are effective only where a property owner is sufficiently wealthy and public spirited to be receptive.

Public Regulation of the Shoreline: The Factor of Hazard

Where public life, health and property is at stake, every legal system on earth recognizes a duty for public authorities to intervene. According to the foremost legal encyclopedia of American law:

> Police power is the exercise of the sovereign right of a government to promote order, safety, health, morals, and the general welfare of society within constitutional limits. . . . on it depends the security of social order, the life and health of the citizen, the comfort of an existence in a thickly populated community, the enjoyment of private and social life and the beneficial use of property. . . . the constitution presupposes the existence of the police power and is to be construed with reference to that fact.
> (Corpus Juris Secundum, "Constitutional Law," sec. 174)

The use of mandatory public authority to promote public safety from floods is found in English history at least as early as the thirteenth century. According to Bosselman et al. (1973, p. 69):

> The marshy condition of many parts of England gave rise to yet another series of land use controls relating to the creation of drainage systems and the prevention of floods. As various tenants constructed seawalls and drainage works on their own property, it soon became readily apparent that negligence on the part of a single tenant could result in the inundation of an entire region. Thus as early as 1250 the land owners of Romney Marsh chose twenty-four 'jurats' to watch over the seawall and water courses, compelling

each owner to maintain in repair walls of a certain length and 'water gangs.' Recalcitrant land owners were fined and their goods subject to seizure by the jurats' bailiff.

In the colonial history of the United States, fire was a more feared threat than flood (particularly since most colonial settlements were wisely sited on elevated ground). According to Bridenbaugh (1964, p. 93):

> By 1690 inhabitants of every colonial village had had to face certain problems of urban living which required solution not by individual but by community effort. In the country a man might construct his home, build his fire, dig his well, erect his privy, and dispose of his rubbish without thought for the wellbeing of his neighbors, but in town these things became objects of community concern and gradually of civic ordinance.

During the nineteenth century, little progress in public environmental regulation occurred. Regulations dealt mainly with the abatement of public nuisance in the form of encroachment on public ways, use of public open space, and preservation of light and air. The latter concern gave rise to the development of building regulations in the latter nineteenth century as a result of the hideous conditions found to exist in the urban industrial slums of England and America.

A major turning point in public land use regulation occurred in the adoption of the first comprehensive land use zoning law by New York City in 1916 and its rapid proliferation elsewhere. Zoning was upheld by the U.S. Supreme Court in its 1926 decision in Village of Euclid v. Ambler Realty Company (272 U.S. 365) The court held that the intermixture of different land uses is inherently deleterious and therefore may be prevented through public land use regulation. The ruling even extended to the separation of residential structures of different types such as apartments and single family homes.

Thus the scope of the regulatory power to control land use was broadened far beyond narrow health and safety concerns. Property values, aesthetics, social values, and municipal physical considerations all have dominated the American law of land use control. It is scarcely surprising therefore that zoning has been widely criticized recently for being the cause rather than the remedy of many metropolitan land use problems (Babcock, 1966).

Paradoxically, as public land use regulation has served questionable goals, it has failed to serve its original and most important purpose, namely the protection of lives and property. While zoning is commonly used to regulate the height, spacing, appearance, and occupany of structures, it seldom serves to prevent them from being located in the path of destruction.

One reason for the delay in protecting hazardous areas has been the belief that regulations which significantly lower the property value of land by limiting development of it are unconstitutional as a "taking of private property without just compensation." This "diminution of value" theory is attributed by Fred Bosselman to a 1922 U.S. Supreme Court decision by Oliver Wendell Holmes in the case of Pennsylvania Coal Co. v. Mahon (260 U.S. 393). This decision held a Pennsylvania law unconstitutional which sought to prevent surface subsidence by prohibiting withdrawal of all available coal from underground mines. While Holmes considered this to be a taking of the mining company's property without just compensation, he distinguished a case in which a similar regulation was upheld in order to protect the employees of the mine itself: "but that was a requirement for the safety of employees invited into the mine. . . . " Similarly, it may be argued that Holmes would approve measures to prevent the unwary from being "invited" to invest their funds and to take up residence in hazardous areas. Justice Brandeis in dissenting to Holmes' opinion states the now well-accepted proposition that "restriction upon use does not become inappropriate as a means, merely because it deprives the owner of the only use to which the property can then profitably be put."

Forty years later, the U.S. Supreme Court was asked to review a local ordinance which terminated the excavation of gravel from a long-established quarry in the interests of protecting children and other residents of surrounding residential areas (Town of Hempstead v. Goldblatt 369 U.S. 590, 1962). Although conceding that the quarry had been there first and that the ordinance banned the most beneficial use of the property, the court placed the burden of proof that the ordinance was unreasonable upon the property owner. In the absence of proof that the ordinance was unreasonable, the court allowed it to stand. From Euclid to the present time, this "presumption of legislative validity" has been applied by courts to save countless zoning measures in the absence of strong evidence that they are unreasonable.

The U.S. Supreme Court has never addressed floodprone area regulations directly and before 1970, few state courts had done so either. In 1953, the California Supreme Court upheld a "beach recreation district" despite the challenge that it is unconstitutional to procure public recreation space through zoning. The court based its approval upon evidence that "plaintiff's property is from time to time subject to erosion and replacement by reason of storms and wave action of the Pacific Ocean; that any residences which could be constructed upon the property would not necessarily be erected on pilings, and reasonable minds might differ as to safety of such residence property so constructed; . . . " (McCarthy v. City of Manhattan Beach, 264 P2d 932).

Unfortunately, this positive and explicit treatment of a flood hazard problem has been seldom emulated in other decisions or jurisdictions. In 1959 the Connecticut Supreme Court gave comparable recognition to physical reality in reviewing the validity of a state encroachment (set-back) line:

> The loss of human life and the destruction of property wrought by the floods in August, 1955, justified the legislature in conferring upon the commission broad powers to adopt preventive measures against their repetition. The trial court found that the encroachment lines . . . accord with sound engineering principles and statutory requirements, and were designed to reduce hazard to life and property in the event of recurring floods. (Vartelas v. Water Resources Commission, 153 A.2d 822)

Another decision by the same court in 1964 disapproved the application of a floodplain restriction (Dooley v. Town of Fairfield, 197 A.2d 770). The plaintiff in this case however had paid a sewer assessment of $11,000 based on the anticipated development value of the land. It was therefore held to be unfair to deny this development value subsequently.

By 1972, the Massachusetts Supreme Judicial Court was satisfied that "the general necessity of floodplain zoning to reduce the damage to life and property caused by flooding is unquestionable" (Turnpike Realty Co. v. Town of Dedham, 284 N.E.2d 891). Thus fifty years after zoning itself was approved, individual states are finally coming to the conclusion that its application to protect life and property in flood prone areas is indeed valid.

But acceptance of the general validity of floodplain restrictions does not mean they will in all cases be acceptable from a technical standpoint nor does it mean that they can be employed to serve other purposes such as protection of aesthetics, wildlife, or prevention of erosion. While each of these is in itself a valid public objective, land use measures must be carefully tailored to a particular purpose and must be no more restrictive than necessary to accomplish that end.

Coastal Hazard Mitigation

Mitigation of the effects of coastal natural hazards is one of several objectives of the Coastal Zone Management Act of 1972 (P.L. 92-583). Among the elements required to be addressed in a proposed coastal plan is the issue of "floods and flood damage prevention, erosion (including the effect of tides and currents upon beaches and other shoreline areas), land stability, climatology and meteorology" (Federal Register, January 9, 1975, p. 1685, section 923.4).

As to this and other coastal planning objectives, Congress requires each coastal state to submit a proposed management program in order to qualify for administrative grant assistance under Section 306 of the Coastal Zone Management Act. Proposed programs must involve any one or a combination of the following general techniques for control of land and water uses within the coastal zone:

A. State establishment of criteria and standards for local implementation, subject to administrative review and enforcement of compliance;

B. Direct state land and water use planning and regulation; or

C. State administrative review for consistency with the management program of all development plans, projects, or land and water use regulations, . . .

In the Coastal Zone Management Act Amendments of 1976 (PL 94-370 Sec. 4) Congress required state "306 plans" to provide:

(a) A planning process for (A) assessing the effects of shoreline erosion (however caused), and (B) studying and evaluating ways to control or lessen the impact of, such erosion, and to restore areas adversely affected by such erosion.

A survey of state coastal management offices conducted in August, 1976, under the auspices of the Institute of Behavioral Science, University of Colorado, disclosed that many states are proposing to use existing legislation of many kinds in the preparation of their 306 plans. The following summary and table of state approaches, while not exhaustive, indicates the diversity and imagination with which states are proposing to meet the Section 306 mandate.

1. Comprehensive State Coastal Zone Regulation

California, Washington, and Rhode Island have conspicuously pioneered the concept of state coastal zone management. Each of these states adopted coastal legislation prior to the federal Coastal Zone Management Act of 1972 and it is their collective experience upon which the implementation of the latter is substantially based. While there are major differences between the three states, several common features may be identified. First the relevant planning areas consist of entire shorelines, not simply discrete landforms or problem areas. Second, administration is largely a state function with specific responsibilities delegated to certain local and regional entities in the cases of California and Washington. Third, state coastal authority extends inland in each case as far as necessary to embrace activities and physical features associated with the coastline. The Rhode Island coastal zone is bounded by the mean high water level but extends inland to include certain categories of major development, intertidal marshes, and shoreline protective works.

TABLE B-1

STATE LAWS RELATING TO COASTAL HAZARD MITIGATION

	Comprehensive Coastal or Land Use	Shoreland Zoning	State Flood-plaining	Critical Areas	Coastal Wetlands	Setback or Encroachment Lines	Beach and Shore Preservation
Alabama	a						
Alaska							
California	b		x				
Connecticut			x		x	x	
Delaware	c				x		x
Florida	d			x		x	x
Georgia					x		
Hawaii	e	x	x			x	
Illinois							
Indiana							
Louisiana					x		
Maine		x	x	x	x		
Maryland	f		x	x	x		x
Mass.					x		
Michigan		x	x				
Minnesota		x	x	x	x		
Miss.					x		
N.H.					x		
New Jersey	g		x		x		
New York			x		x		
N.C.	h		x	x	x		
Ohio							
Oregon	i			x			
Pa.							
R.I.	j				x		
S.C.							
Texas					x		
Virginia					x		x
Washington	k		x		x		
Wisconsin		x	x				

Sources: 1) CZM State Reports (Handbook, Part IV).
2) Sixth Annual Report of the U.S. Council on Environmental Quality, 1975.

[a] Ala. Coastal Zone Development Act of 1973.

[b] Calif. Coastal Zone Conservation Act of 1972 (Final Plan adopted August, 1976). San Francisco Bay Conservation and Development Commission Act of 1969.

[c] Del. Coastal Zone Act of 1971.

[d] Florida Land and Water Management Act of 1974.

[e] Hawaii State Land Use Zoning Act.

[f] Md. State Land Use Act of 1974

[g] N.J. Coastal Area Facilities Review Act of 1973.

[h] N.C. Coastal Area Management Act of 1974.

[i] Ore. Land Conservation and Development Act of 1973.

[j] R.I. Coastal Management Act of 1971.

[k] Wash. Shoreline Management Act of 1971.

California's interim coastal permit authority applies to a zone 1,000 yards landward from the mean high tide line; coastal planning authority extends even further, to the highest elevation of the nearest coastal mountain range except in certain urban counties.

These state coastal permit programs may be readily adapted to incorporate new perceptions of natural hazards. The Rhode Island Coastal Management Council, for instance, denies permits for development on "undeveloped" beach areas and seeks to limit new construction on dunes or beaches anywhere in the state. Furthermore, the towns of Westerly and South Kingstown, Rhode Island, augment the state requirements with their own minimum setbacks from mean high water for new construction (Miller, 1976).

2. Shoreland Zoning

A variation on the foregoing approach is "shoreland zoning" as practiced in the Great Lakes States of Minnesota, Wisconsin, and Michigan, and the Atlantic coast state of Maine. Shoreland zoning involves a mandate by the state legislature that local governments shall adopt satisfactory land use regulations for their river and lake shoreline areas or such regulations will be adopted on their behalf by the state. In either case, administration of regulations once adopted remains with the local government. The state performs a "watchdog" function to make sure that the regulations are faithfully applied.

It is not yet clear to what extent shoreland zoning in practice reflects natural hazard considerations. Experidnce to date has largely been devoted to achieving a minimum level of regulation in affected communities. In Maine, it is reported that certain coastal towns have adopted shoreland zoning although they have no other zoning whatsoever in their jurisdiction. Presumably, flood and erosion factors may be incorporated into the criteria by which states review or establish local regulations.

3. Mandatory Floodplain Zoning

The "Hobson's Choice" of shoreland zoning has been applied with apparent success in New York State to all communities with recognized flood hazard areas. To date, the state has imposed regulations on about twenty-four communities. Otherwise incorporated cities, towns, and villages have cooperated in adopting their own regulations subject to state guidelines. (Source: William Daley, New York Department of Environmental Conservation). As shown in Table B-1, several other states have adopted some form of state-level floodplain management legislation.

4. Critical Areas Programs

The Model Land Development Code proposed by the American Law Institute in 1975 proposes that states assume particular responsibility for so-called "critical areas." Such areas may be defined in various ways, based on physical, cultural, economic or aesthetic criteria. As applied to coastal zone management, the critical areas approach is more restrictive geographically than the techniques described above. It dovetails with the concept of "geographical areas of planning concern" which the Federal Office of Coastal Zone Management urges should be identified by states as part of their coastal plans.

Critical areas programs have been adopted to date by Maine, Minnesota, Maryland, Florida, North Carolina, and Oregon. Most programs provide for a broadly based process for nominating "critical areas." This procedure yields areas of ecological, wildlife, geologic, or other unusual interest, but it may well overlook areas of particular hazard concern. It is recommended that state agencies responsible for selection of critical areas give consideration to sites incurring flood, erosion, seismic, volcanic or other hazardous activity. OCZM, in fact, recommends designation of "areas of significant hazard, as geographic areas of planning concern" (Federal Register, 1973, 1975).

5. Coastal Wetland Programs

Several states intend to rely heavily on their coastal wetlands permit program for CZM purposes. With the recent attention given to the importance of coastal wetlands in the ecological food chain, and the extent of their loss due to development along the Atlantic and Gulf coasts, many states have implemented coastal wetland programs. (See Table B-1.)

The states differ as to the designation of wetlands, inclusion of related non-wetland areas, permitted uses, and administrative procedures. In general, state courts appear to be upholding state limitations upon development in coastal wetlands where reasonably and fairly applied, (e.g., Just v. Marinette County, 201 N.W.2d 761, Wis., 1972; Sibson v. State, 336 A.2d 239, N.H., 1975; Candlestick

Properties v. San Francisco Bay Conservation and Development Commission, 89 Cal. Rptr., 897, 1962).

While most state programs regulating wetlands are based on their ecological value, it is clear that such areas serve to mitigate the effects of coastal flooding and erosion. Wetlands absorb the energy of coastal storms and dampen tidal surges in estuaries. Filling and development of such areas not only destroys this effect but exposes the resulting new structures to direct assault by wind and waves.

6. Mandatory Setbaks

A mandatory setback or "encroachment line" may be legally imposed to restrain all further development or fill within a specified distance of a body of water. In Connecticut, encroachment lines have been established to protect the 100 year floodplain of portions of the Connecticut River and certain other streams (cf. Vartelas v. Water Resources Comm. 153 A.2d 822, 1959). Its legal authority to establish such limits extends to tidal waters but so far this tool has not been applied to the Connecticut coastal zone.

Great Lakes states are turning to mandatory setbacks as a response to severe erosion occurring due to high lake levels. Recession rates may be estimated (albeit crudely) by extrapolating from erosion rates in the recent past. Michigan is proposing a statewide setback for lakeside development equivalent to thirty years of erosion (the average term of a mortgage). Illinois is considering a 100 year erosion setback, a distance of possibly 200 feet along its "North Shore" bluffs.

Mandatory setbacks are perhaps less useful along ocean shorelines where beach and dune configurations are likely to shift drastically. However, if used in conjunction with other tools dedcribed above, the mandatory setback is a sensible response to obvious coastal storm hazard. Thus, certain Rhode Island towns have adopted their own setback regulations as a supplement to the state coastal zone permit program. Glynn County, in Georgia, has done the same. Some states have combined minimum setbacks with other measures to protect dunes, beaches, and shoreline features.

7. Development Moratoria in Coastal Areas

Most of the measures described above require extensive research and planning studies as a prerequisite to final implementation. Accordingly, some states have adopted an interim period of control through state legislation to be superseded by a final plan. This has been the case in Washington, California, New York (as to its tidal wetlands) and Flordia. Considerable delay and expense to private owners may ensue from moratorium controls which attempt to preserve the status quo . Nevertheless courts are proving to be sympathetic with well-expressed public objectives in such cases. The New Jersey court in Cappture Realty Corp. v. Borough of Elmwood Park, 313 A.2d 624, 1973, involving a moratorium pending construction of a flood control project, stated:

> The enactment of interim ordinances has been upheld as a recognized and logical addition to comprehensive municipal planning during periods required to create or revise comprehensive zoning in plans . . .
>
> Indeed it is precisely because of the exigencies surrounding the requirements for planning and adequate action by municipalities that interim ordinances have been upheld.

In general, states are pursuing many avenues to cope better with the challenge of coastal zone management. Courts seem generally to uphold their efforts. It is vital that natural hazards be regarded as an integral factor and concern in the implementation of these programs. Otherwise, coastal zone management may well be in vain.

REFERENCES

Babcock,, R. M., The Zoning Game. Madison: University of Wisconsin Press, 1966.

Bosselman, Fred P., David Callies and John Banta, The Taking Issue A Study of the Constitutional Limits of Governmental Authority to Regulate the Use of Privately Owned Land Without Paying Compensation to the Owners. Washington: U.S. Government Printing Office, 1973.

Bridenbaugh, Carl, Cities in the Wilderness. New York: Capricorn Books, 1964.

Federal Register. Jan. 9, 1975, p. 1687, Sec. 923.13 (7); Nov. 29, 1973, p. 33046, Sec. 920.13 (7).

Miller, H. Crane, The Ocean's Reach. New England River Basins Commission, February, 1976.

C. "Modified Mercalli Intensity Scale of 1931" (Abridged) from Harry O. Wood and Frank Neumann, in Bulletin of the Seismological Society of America, Vol. 21, No. 4, December, 1931.

The most commonly used earthquake intensity scale is the modified Mercalli. This scale was developed to measure the effect of an earthquake on people, structures, and the earth's surface, and is calibrated to twelve degrees of severity; (I) denoting barely perceptible effects, and (XII) signifying total destruction.

I. Not felt except by a very few under especially favorable circumstances.

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing truck. Duration estimated.

IV. During the day felt indoors by man, outdoors by few. At night some awakened. Dishes, windows, and doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings, with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any (masonry), structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

D. "Scenario of Hurricane Disaster in Miami, Florida," from Gilbert F. White and J. Eugene Haas, Assessment of Research on Natural Hazards, 1975.

The threat posed by hurricanes at many points along the South Atlantic and Gulf coasts is dramatized by an account of vulnerable population and property in dynamic interaction in Miami, Florida. The following is a current judgment of the probable results of a hurricane of a given strength striking a sector of the Florida shore where the parameters of occupance and adjustment are known. It concentrates on threats to life and does not estimate total property losses.

The meteorological catalyst is a large, slow-moving, wet hurricane making landfall south of Miami. Specifically, it is a hurricane with a central pressure of 925 mbs and radius of maximum winds of 15 miles. This is equivalent to Donna (1960), Carla (1961), and Betsy (1965), and much less severe than the Keys storm of 1935, which drowned 730 people in that relatively low density population area. It passes just south of Key Biscayne and moves onshore at 15 mph at the new residential community of Saga Bay (see Figure D-1).

Under these conditions, the National Hurricane Center in Coral Gables issues a warning for residents of Key Biscayne, Virginia Key, and south Miami to evacuate. Such a warning is normally made with at least 12 hours of daylight remaining before the predicted landfall of the hurricane.

Key Biscayne and Virginia Key are about five miles off the coast of south Miami. Virginia Key is occupied by a sea aquarium, the oceanographic laboratories of the University of Miami, and research facilities of the National Oceanic and Atmospheric Administration. Key Biscayne, a large residential community of mostly wealthy residents, is attractive for residential location due to the close proximity of the water and its distance from the more congested mainland. The elevations of these above mean sea level range from two or three feet to about ten feet, with an average of approximately five feet. Rickenbacker Causeway, a two-mile bridge across Biscayne Bay bisected by a drawbridge, connects Key Biscayne and Virginia Key with the mainland. At best, it requires at least nine to ten hours to evacuate the approximately 10,000 inhabitants.

A number of possible events could preclude successful evacuation of the entire population. First, not all of the 12 hours of warning are available for evacuation. As much as

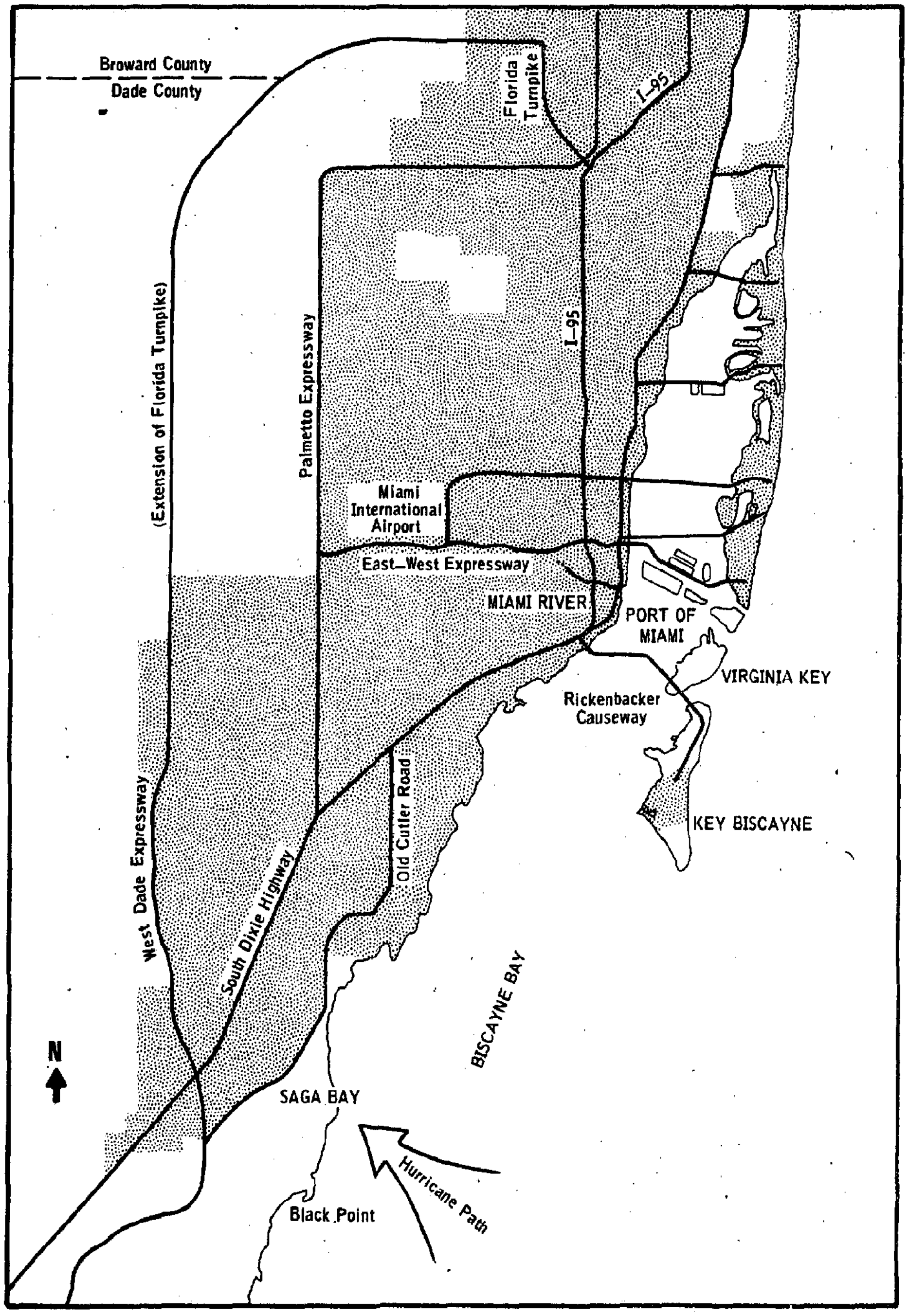

FIGURE D-1
MIAMI AND VICINITY

six hours prior to a slow-moving hurricane's landfall, storm surge may cause tides to begin rising, thereby flooding some low points on roadways used for evacuation, and bringing automobile traffic to a halt. Even before the storm surge hits its peak at the coast, traffic is snarled by a combination of congestion, weather, flat tires, and automobile accidents. Residents of Key Biscayne and Virginia Key must act swiftly to evacuate once the warning is received in order to avert a major disaster; those not promptly heeding the warning are trapped by the time the magnitude of the hurricane becomes visibly apparent. Since a large proportion of Florida's population has never witnessed a severe hurricane, a warning response rate of less than 50% can be expected.

The drawbridge represents another weak link in the escape route. With the onset of a major storm, marine traffic through the drawbridge increases as vessels seek the shelter of the Miami River and other havens northward. Commercial marine traffic is normally heavy, and several times in past years, barges (which are now pushed rather than pulled by tugboats) have jack-knifed while passing through the raised bridge and jammed its mechanisms. Rising winds and heavy seas contribute to the probability of such an event. Even without such an accident, drawbridges periodically fail and lock in the up position.

Severing of the causeway for any reason means large fatalities from storm surge in the trapped population. Alternative escape routes are severely limited by time and geography. No large boat landings exist on either Key Biscayne or Virginia Key, so only small craft can be utilized for an evacuation by sea. Only a handful of people can be transported at a time, and organizing and carrying out such an operation consumes such precious time. Moreover, the danger to those in boats increases rapidly as the hurricane approaches.

Evacuation by air is precluded by the lack of an airport and the danger of utilizing helicopters in high winds. Vertical evacuation into high-rise condominiums is an increasing possibility with new construction, but is limited by space and the willingness of owners to allow public access to their private property. (The problem is analogous to that for private atomic bomb shelters during the 1950s.) The five- to ten-foot land elevations afford minimal shelter from the wind-driven storm surge waves of 10-15 feet along the right side of the hurricane.

Mainlanders also experience severe difficulties in their attempts to evacuate. A storm surge six hours in advance of the hurricane's center catches many residents still preparing to leave. Heavy rainfall and high winds also hamper evacuation attempts.

Saga Bay is an excellent example of how the hurricane disaster potential is exacerbated by coastal development. The area is located south of Miami in the area below Old Cutler Road and above Black Point; it is anticipated to house a population of approximately 100,000 to 150,000 initially. Feasibility of the development was enhanced by construction of the West Dade Expressway, which is connected to Saga Bay by the Old Cutler Road. Elevation of the Saga Bay area varies from sea level to five feet above mean sea level.

In order to meet Federal housing regulations, houses are elevated five feet above mean sea level on fill dug from nearby man-made lakes. The Saga Bay developers, however, also tore out the mangroves along the coast, which are unsightly and ill-smelling. These mangroves formerly provided one of the few effective barriers to storm surge, and the smooth, cleared beaches that are being built invite the unrestrained sweep of storm surge across the entire area. Storm surge accompanying a hurricane of magnitude postulated cannot be deterred by the slight elevation of the houses

The evacuation route for Saga Bay residents is along Old Cutler Road to the expressway and then north. While Old Cutler Road generally has an elevation of five to ten feet above sea level, and might not initially be affected by storm surge, heavy rainfall swells Black Creek beyond its banks and cuts the shortest route to the expressway.

Travel north on Old Cutler Road carries evacuees to the already overburdened and inadequate Dixie Highway, and into the congestion of evacuees from Key Biscayne, Virginia Key, and Coral Gables at the intersection of the Rickenbacker Causeway, Dixie Highway, and Interstate Highway 95. Regardless of the direction of travel on Old Cutler Road, evacuees from Saga Bay encounter serious congestion and slow-moving traffic as the capacity of the road is exceeded and the weather deteriorates. Time runs out for many as they find themselves trapped in their automobiles when the hurricane hits.

Reaching the West Dade Expressway does not mean safety, however, and further obstacles must be overcome. The expressway connects with the Florida Turnpike, which is located west of most residential development in the Miami area. It too becomes severely overburdened as Miami residents evacuate. The Palmetto and the North-South (I-95) Expressways have major tie-ups, as do all northbound streets, and travel is induced westward to the turnpike extension.

The severity of traffic jams in Miami is made worse by the interaction with two evacuation operations, those for boats, and those for people by automobile. Slip lease agreements between boat owners and the marinas normally stipulate that owners will evacuate their boats when a hurricane warning is received. At the time of evacuation, these boats are instructed to proceed to the mouth of the Miami River to be escorted up the river in flotillas. Other than the expressways, all of the major north-south arteries in Miami cross the Miami River and, therefore, have drawbridges. The use of flotillas is designed to minimize the raising of bridges, but major automobile tie-ups occur; once the flow of traffic is interrupted it takes considerable time to return to normal.

In addition, the evacuation of boats poses a serious threat of a catastrophe at sea. There are roughly 10,000 small craft registered in Biscayne Bay, but only 1,000 of them can be accommodated up the Miami River. When the river is full, boats are turned away to seek another refuge. No other shelter is close at hand, however, and many boats are caught in open water by the hurricane.

Flooding hampers evacuation operations, as well as severely damaging property. Much flooding is caused by the South Florida Water Control Conservation Project, which is a large network of canals constructed by the Corps of Engineers to prevent flooding of agricultural land in south central Florida. These canals flow to the sea through most residential communities in Dade and Broward Counties and, in fact, provide high-priced, waterfront sites. With the onset of storm surge, however, their flow to the sea will be blocked and with heavy rainfall they can be expected to flood both streets and property.

In sum, the total loss of life is high. A storm surge well in advance of the hurricane's center catches many still preparing to evacuate. Flooding of escape routes due to heavy rain exacerbates the severe traffic tie-ups which are normally expected with a large number of automobiles. (Rush hour traffic probably represents less than 25% of the traffic which could be expected with a warning to evacuate, and even this amount cannot be accommodated without major delays.) Warning and evacuation as they now are planned and proceed are inadequate responses to the posited threat.

E. "Barrier Islands - Hurricane Adjustments" and "Mainland Coasts - Earthquake Adjustments," Sample outlines of possible adjustments to regional natural hazard problems.

BARRIER ISLANDS - HURRICANE ADJUSTMENTS

POSSIBLE ADJUSTMENTS	EFFECTIVENESS: *Harmful or Ineffective*	EFFECTIVENESS: *Beneficial*	ACCEPTANCE	POSSIBLE ACTION
PROTECTIVE STRUCTURES	1. Causes erosion of beaches 2. Creates false sense of security 3. Encourages development in hazard areas 4. Destroys aesthetics and recreational opportunities of beach	1. Prevents property damage and can save lives	GOOD-- but some realization by local officials and residents of environmental damage caused by structures. also, local officials realize $ cost is prohibitive to local governments.	Any future construction of protective structures should be part of a comprehensive disaster mitigation program which should be formulated after consideration of a wide range of alternatives. Due to their significant impact on beach aesthetics and recreational opportunities as well as their great cost ($1000/sq. ft. or $5 mil./mile), protective structures should be very carefully studied before inclusion in a hurricane protective program.
FLOODPROOFING	1. Can create false sense of security 2. Some poorly done flood-proofing attempts can cause more damage	1. Saves structural damage, $ and lives 2. Encourages wise land use practices in hazard areas	FAIR-- mostly new efforts done in connection with Flood Insurance Program. previous efforts scattered and token. Residents either ignorant of proper methods or apathetic.	Minimum Building Standards for hurricane prone areas should be adopted by a State insurance agency. The cooperation of local architects and builders will be required for implementation of the standards.

	3. Enforcement of new building codes a problem--many variances granted			Governor should suspend unsafe construction practices in hazard areas and by regulation place new standards into effect.
	4. Not widely used in old residences			The enforcement of FIA building requirements for flood hazard areas should be carefully monitored to ensure compliance.
FLOOD INSURANCE	1. May encourage developemnt of vulnerable areas	1. Those who take most risk will bear more of cost burden--saves tax-payers $	FAIR TO GOOD-- Complaints over restrictions by developers and some residents	Assess the effects (social, economic, as well as disaster prevention) of the Federal Flood Insurance Program on coastal communities.
	2. Will increase costs slightly to meet standards	2. Requires flood-proofing of structures	Large support by elected officials, especially County Judges and State Senators	Investigate the possibility of establishing a flood insurance pool thus privately financing costs rather than accepting Federal subsidy.
EMERGENCY PREPAREDNESS	1. Local emergency plans vague in critical area of evacuation	1. Local NWS very active in hurricane warning preparedness	FAIR-- most residents definitely aware of threat of hurricane hazard, however, many long-term residents have philosophy of defying the storms, refusing to evacuate, "taking it," etc.	Require a comprehensive State disaster plan to include separate section on <u>prevention</u> and <u>minimization</u> of injury and damage due to hurricanes and other natural hazards.
	2. Plan more reactive-oriented than preventive			Require each local disaster agency (county or municipal) to incorporate preventive measures into local plan as a condition for funds.

		2. Local emergency plans usually contain special section on hurricanes		Give Governor power to order evacuation from disaster-threatened area. Funds should be provided for a full-time disaster coordinator for all urban coastal communities and for each rural county.
	3. Local disaster coordinator unable to devote enough attention to preparedness			Local officials should clearly state evacuation policy and roles in Emergency Plan.
RELIEF AND REHABILITATION	1. No city or state policy on reentry into disaster area	1. Good immediate response and prior preparation by local Red Cross, Hospitals, etc.	GOOD-- Immediate period following hurricane is one of co-operation on part of citizens and officials. Strong desire to move quickly on making repairs, cleaning up, etc.	Governors should control ingress and egress from a disaster area and should assume this authority to reduce confusion in the immediate post-disaster period.
	2. Lack of amphibious equipment			Amphibious vehicles should be required as part of every coastal disaster plan. State Division of Emergency Services or similar agency should help local governments in acquisition of such vehicles.
	3. No long-term recovery or rehabilitation program provided for in Emergency Plan			To ensure beneficial long-term recovery a model 90-day post-disaster recovery plan should be included in the Comprehensive State Disaster Plan. An inter-disciplinary team approach (utilizing architects,

				planners, economists, sociologists, etc.) could be used and local reconstruction agencies could be formed using Title VIII funds from the Federal Disaster Relief Act of 1974.
LAND USE MANAGEMENT	1. Not used extensively in past.	1. Some attempt to regulate traffic on beaches.	POOR-- Land use management is politically sensitive subject	State should identify areas particularly susceptible to subsidence, flood or other catastrophes and keep land use and construction of structures under study.
	2. Failure to control development.	2. Control of development.	Some local officials realize the need for wise management of land, but local economic pressures often interfere.	The Governor should suspend unsafe land use controls and place new controls in effect. Enact and enforce dune protection bills.
	3. Zoning plans rarely have connection with hurricane damage prevention.	3. Some attempt to locate parks, golf courses, etc. in critical environmental areas.		Pass a workable disclosure act for natural hazards.
	4. Purchasers of land are often not aware of the hazards involved.			

MAINLAND COAST - EARTHQUAKE ADJUSTMENTS

POSSIBLE ADJUSTMENTS	EFFECTIVENESS: *Harmful or Ineffective*	EFFECTIVENESS: *Beneficial*	ACCEPTANCE	POSSIBLE ACTION
EARTHQUAKE REDUCTION	1. Scientifically unfeasible at present 2. No defined responsibility for effects of "small" triggered quakes.	1. Would probably eliminate large events.	POOR-- Issue is too technical and speculative.	More research could be done on both the techniques of reduction and on responsibility for "side-effects."
EARTHQUAKE RESISTANT CONSTRUCTION	1. Can be costly when modifying existing structures. 2. Encourages development in hazardous areas. 3. May create false sense of security. 4. Some difficulty enforcing new as well as old codes.	1. Saves lives and property damages.	FAIR TO GOOD-- Opposition centers on increased building costs. More widely accepted for buildings which are occupied by public (e.g., schools or hospitals). Where building codes are adopted the enforcement may be weak.	Future construction should incorporate minimum safety standards which consider possible earthquakes as a criterion. These standards will require the cooperation of architects and builders for implementation.

LAND USE MANAGEMENT	1. At present, risk cannot be sufficiently identified at a micro-level to make this a practicable adjustment.	1. Reduces lives lost and properties damaged by allowing only certain types of development in hazard areas.	POOR-- Economic interests in land development leads to opposition except in areas which have accepted land planning for other purposes.	Need techniques for more clearly defining areas at risk. Should provide hazard disclosure to prospective land purchasers, which may require passage of a special bill.
EARTHQUAKE INSURANCE	1. May encourage development of hazardous areas. 2. To reduce losses, insurance must be combined with other adjustments such as resistant construction.	1. More equitably distributes hazard costs, i.e., those who take most risk pay most.	POOR-- Most homeowners have not purchased. Expensive for commercial and industrial buildings.	Investigate the reasons why adoption of this adjustment has been slow. Possibly generate a campaign to insure public awareness of its availability. Investigate the effects on other adjustments of adopting insurance.

EMERGENCY PREPAREDNESS	1. Become outdated very quickly and require constant revision. 2. Plans are reactive rather than preventive in nature. 3. Requires full-time disaster coordinator	1. May reduce number of lives lost. 2. Many emergency plans contain specific sections on earthquakes.	GOOD-- Many individuals have made some emergency provisions. Most communities accept help in emergency planning activities.	Require state and local plans to include specific sections on preparedness for earthquake disasters, and provide for frequent revisions and updating. Provide funds for full-time disaster coordinator.
RELIEF AND REHABILITATION	1. May increase potential losses over time by reducing incentive to seek alternative adjustments. 2. Reactive vs. preventive although some prior planning required.	1. Provide good immediate response.	GOOD-- Most people receptive to Government relief activity.	Should prepare well in advance, a recovery plan to be used when disaster occurs. This could employ an inter-disciplinary approach and might utilize funds from Title VIII of the Federal Disaster Relief Act of 1974.

EARTHQUAKE PREDICTION	1. Not feasible at present.	1. Could reduce number of lives lost as well as property damaged.	FAIR-- Mixed feelings on feasibility. Some feel it will have a few negative consequences.	Further research needed both on prediction techniques and on societal response to predictions.
	2. Response uncertain.			

F. A Check-List of Possibly Relevant State Programs

A wide range of state regulations and incentives touch upon the management of hazards in coastal areas. The following check list suggests the number and diversity of those programs. It is not intended to be comprehensive but it does indicate the variety of measures that may affect an area's vulnerability to extreme events.

1) State disaster - civil defense programs. What is on the books, how is it being used, what is the state doing in response to PL93-288?

2) Land sales disclosure legislation. If the state has such an Act, does it include a provision for natural hazards? If not, would it be helpful to advocate one of narrow scope for coastal hazards?

3) Local authorities. Do the local governments (especially counties) have any substantial general authority over building standards or land use? If so, O.K. If not, do they have any special, narrowly focused powers of this sort that can be used to cope with disasters? For example: (a) flood plain regulatory authority to the extent required to meet FIA requirements, or (b) can general authority to "...protect health and safety..." of the population be used in the natural hazard situation?

4) Special insurance provisions. Does the state have any special insurance pools or associations to cover high hazard situations and if so, can these be used as a force in influencing coastal development decisions?

5) Public works funding. What, if any, special public works financing programs does the state have that might be useful in coastal situations? For example, if beaches have a proven history of public use, might state road or recreation funds be used to counteract erosion?

6) Public awareness efforts. Are there accepted, in-place information dissemination programs that could be utilized such as agricultural extension service? Using them may be beneficial in several ways: (a) they are apt to have an in-place, operational network, (b) their credibility is often accepted, and (c) often they are seeking new areas of involvement.

7) Public utilities regulation. Does the state's Public Utilities Commission require (or permit as a tax deductible item) electric and phone companies to disseminate select public interest materials? These companies reach virtually every household with billings, and can be quite helpful.

8) Highway programs. Does the Highway Department take account of hazard vulnerability in laying out or improving roads in hazardous areas?

9) Sewer and water supply improvements. Is there a state agency which approves plans for extensions of sewers and water supplies? If so, does it consider what effect those extensions would have on development in vulnerable areas?

GPO 913-152